

# TALKING ELECTRONICS<sup>®</sup>

\$2.20

\$3.00 NZ

## Issue No 14

### CONTINUITY TESTER

- \* INPUT/OUTPUT BOARD FOR THE TEC
- \* MICROCOMB 1. PART II



CRYSTAL OSCILLATOR

CO-ORDINATOR



GUITAR PRACTICE AMP

# TALKING ELECTRONICS

## Editorial...

A week may be a long time in politics, but so it is too in electronics.

Today's super seller may be tomorrow's forgotten wonder.

Take the rise and fall of the Personal Computer.

From a tentative start, the PC rose rapidly to become one of the most popular sales lines ever. The market seemed insatiable. As fast as a new model was released, it was snapped up.

But then the crunch came. The bubble burst and saturation occurred. The boom of last week turned into the fizz of this week.

How or why the abrupt end occurred, nobody seems to know. Everyone got caught. The biggest losers were the importers. With thousands of boxed computers lying in their warehouses, many have just let them sit; waiting and hoping for a change in the market.

Even though we can buy a model with twice the features, cheaper than last year, nobody wants them.

Maybe it was the realisation that the personal computer is really little more than a glorified games machine, that started a nationwide re-think. Or was it the improvement in graphics on the arcade machines, that made their graphics look so purile?

In any case, the secondary effect of the slump has been to create an absolute glut of chips on the open market.

All those used in one or more of the popular computers are now available by the million!

To clear this back-log, chip production has slowed to a mere trickle and prices have fallen to a level below the actual cost of manufacture.

A 64k DRAM can now be bought in small quantities for 4c less than production cost!

Sadly, the slump is exactly as we predicted.

Computers failed to interface to the real world and although they appeared exciting within themselves, they could not be readily connected to external appliances and gadgets.

Had someone produced a universal interface consisting of say a robot arm, a telephone interface and an alarm system, the capability of the PC would have been extended enormously and its popularity would still be with us.

Until someone comes up with a useful adaptor like this, I cannot see things improving.

We at TE are just as keen as you to see a turn around, as the TEC computer and Microcomp are ideally suited to interfacing to a robot arm.

The only thing holding things up is the non-availability of gearboxes and motors etc.

Let's hope someone has the foresight to produce a range of mechanical units at an economical price so that our ideas for automotives and robotics can come to fruition.

As soon as something comes along, we will be the first to let you know.

*Colin Mitchell.*

## PUBLISHER

TALKING ELECTRONICS is designed by Colin Mitchell of CPW INDUSTRIES, at 35 Rosewarne Ave., Cheltenham, Victoria, 3192, Australia. Articles suitable for publication should be sent to this address. You will receive full assistance with final presentation. All material is copyright however up to 30 photocopies is allowed for schools and clubs.

\* Maximum recommended retail price only.

Vol. 1 No: 14.

## INDEX

4	CUMULATIVE INDEX
5	CONTINUITY TESTER
9	TEC 1A & 1B COMPUTER
21	CRYSTAL OSCILLATOR
23	INPUT/OUTPUT MODULE
27	GUITAR PRACTICE AMPLIFIER
31	ELECTRONICS Stage-1 REPRINT
37	SUBSCRIPTION FORM
39	KIT PRICES
40	ORDER FORMS
47	CO-ORDINATOR
49	SHOP TALK
54	10 MINUTE DIGITAL COURSE
59	MICROCOMP-1 PART 2
75	PC ARTWORK
76	Z-80 CODES EXPLAINED PART 2.

TALK-TRONICS	22
TALKING ELECTRONICS	2, 37, 52
EXPERIMENTER PARTS Co.	53
AUST. DIGITAL ELECTRONICS SCHOOL	57, 58

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For all those who have asked to see a shot of me, I have reluctantly included this recent pose. See, I'm just a normal balding, existentialist.



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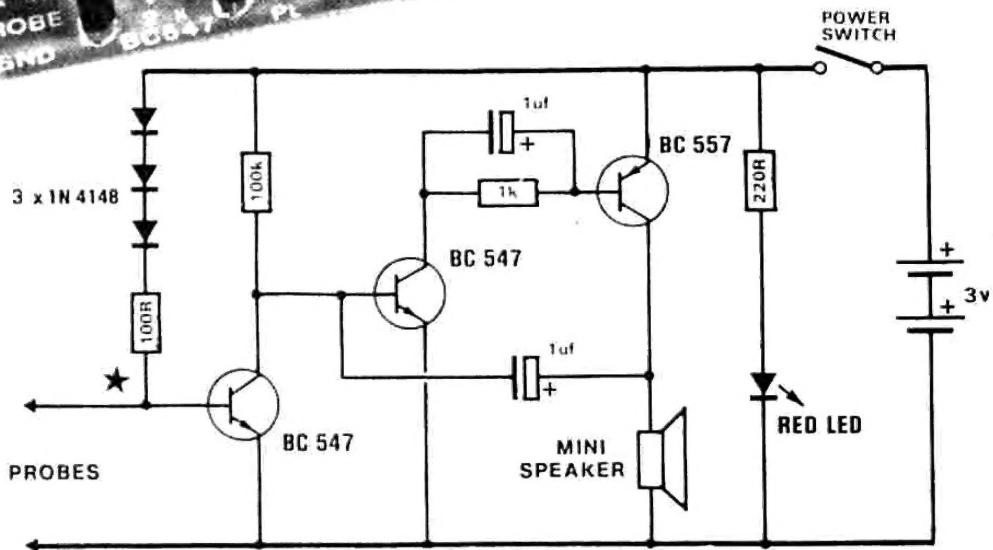
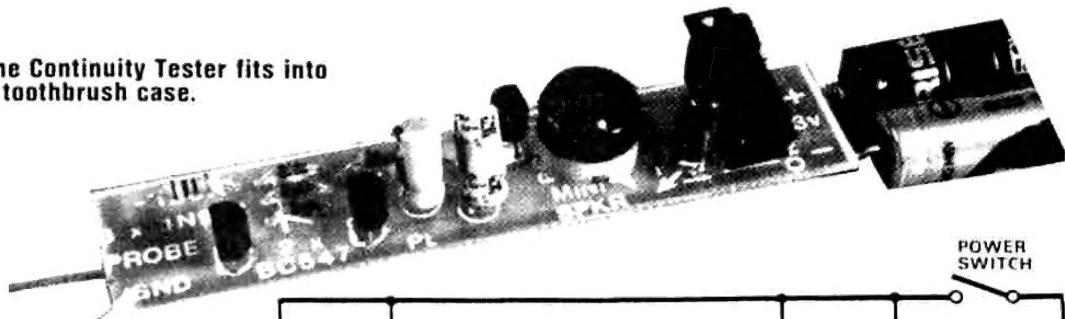
COVER PHOTO: The cover photo shows a Z-80 sitting on a micro-photograph of the internal workings.

# CONTINUITY TESTER

Kit of parts: \$5.60  
PC Board: \$2.10  
Complete: \$7.70

THE THIRD IN OUR 'TEST PROBE' TRIO...

The Continuity Tester fits into a toothbrush case.



**CONTINUITY TESTER CIRCUIT**

The continuity tester is the third and final piece of test equipment in the 'test probe' trio.

On the face of it, a continuity tester seems pretty unimportant and you may be tempted to use a multimeter for the job.

But 'horses for courses' is what I always say. The right tool for the application. A multimeter might be alright for some applications but if you are troubled with a nasty fault in a digital project, the continuity tester is faster, better and easier to use than anything else.

It is specially designed for the job and has three very interesting features.

Firstly it gives an audible indication so that you can keep your eyes on the job. This is important when making a continuity check between adjacent pins of a 40 pin IC or on a closely packed bus network such as the data or address bus.

You cannot afford to take your eyes off the board as either the probe will slip off the track or you will miss one of the lines!

Secondly, its response-time is very brief so that you can make contact in a sweeping or stroking motion so that a number of lines can be swept in the one operation.

And thirdly, the continuity tester responds only to a definite short circuit or one in which the resistance is 150 ohms or less.

It will not respond at all to values above 180 ohms and most important it will not respond to the voltage drop across a diode.

This is where the multimeter falls down.

When you are measuring between some of the lines in a digital circuit, the impedance will be quite low or a protection diode will be in the circuit.

## PARTS LIST

- 1 - 100R 1/4watt
- 1 - 120R (for mod.)
- 1 - 220R
- 1 - 1k
- 1 - 100k
- 2 - 1uF electro
- 3 - 1N 4148 diode
- 2 - BC 547 transistors
- 1 - BC 557 transistor
- 1 - 5mm red LED
- 1 - Mini speaker
- 1 - DPDT slide switch (or SPDT)
- 2 - AAA cells
- 1 - paper clip
- 10cm tinned copper wire
- 50cm Hook-up flex
- 1 - CONTINUITY TESTER PC BOARD

The resultant reading on a multimeter will be low (nearly full-scale deflection) but it will be difficult for you to determine if the meter is picking up the voltage drop across a diode or detecting a very low resistance. Apart from this, the time taken for the needle to swing across to its final reading, makes the multimeter approach very slow.

The continuity tester eliminates these problems.

We have found it invaluable for diagnosing the TEC's that have come in for repair. Most of the problems have been shorts between lands or open connections in one of the buses.

This is how we use the tester:

Once we have established that the fault lies in the trackwork (all the chips have been replaced and the system remains dead) we test each pin of the Z-80 against every other pin of the chip. This is actually 40x40 tests and by using the continuity tester it is simplified to only a few operations.

Firstly place the wander lead on pin 1. With the tester turned ON, start at the top of the other side of the chip and quickly wipe the probe down the 20 pins. Repeat for pins 20 to 1. The only time you will hear a beep is when the two probes

touch. If a short beep is heard at any stage during the test you should go back and determine if the two lines are joined or if a fault exists.

Continue this procedure with pins 2, 3, 4 etc and very soon you will have covered all 40 pins.

By doing this you will have also covered the bus lines on the EPROM and RAM, however they can be individually checked if you like.

The next part of the diagnosis is to check the continuity of each line in the data and address bus. For this you will need a circuit diagram and pin-out data. Start at data line D0 and check D0 on the EPROM and also the RAM. If a tone is heard, the line is continuous.

It is essential to carry out all these checks as you don't know the exact location of the fault and most faults will be found with a systematic approach.

### HOW THE CIRCUIT WORKS

As we have mentioned above, the circuit detects resistance values of 150 ohms or less between the probes and allows an oscillator to turn ON and produce a tone in the mini speaker.

A LED is also included on the board to indicate when the unit is switched ON as the electronics consume about 2-4mA and thus the battery would eventually go flat if the tester were left on for long periods.

Actually the circuit doesn't detect resistance at all. It detects threshold voltage across the base-emitter junction of a gating transistor.

When the tester is in the "rest" state, the first transistor is turned ON and this inhibits the oscillator.

It gets its turn-on voltage via the 100R resistor. The 3v supply is passed through 3 diodes which drop a total of 1.9v, leaving 1.1v for the base bias.

When the transistor is turned ON, the base-emitter voltage (the junction voltage) is .7v and thus .4v is dropped across the 100R resistor. This means we have only .4v leeway for the batteries and when they drop to below 2.6v, the tester will fail to work. That's why we have to conserve battery voltage as much as possible by putting an indicator LED on the project to prevent it being left on.

0.4v across the 100R resistor delivers 4mA into the base of the gating transistor and this keeps the oscillator circuit in the OFF state.

When a resistance of 150 ohms or less is placed between base and emitter, the voltage on the base falls sufficiently to turn the transistor OFF.

This allows the 2-transistor feedback oscillator to come into operation and produce a tone in the speaker.

A diode placed between the base and emitter of the first gating transistor will have no effect on the circuit as it will allow .6v to .7v to be present across the probes and thus the first transistor will not change state. The voltage must drop to .5v or less for the circuit to change and this requires a resistance of about 200 ohms.

The two transistor feedback oscillator is set into motion by the 100k base bias resistor.

This turns on the first transistor and thus its collector voltage falls. The collector is connected to the base of the second transistor in the oscillator and this is also turned on.

The result of this action is to raise the voltage of the collector and as you can see, the mini speaker is connected to this lead. Thus a voltage appears across the speaker.

Also connected to the collector is a 1uF electrolytic and it is presently in the discharged state.

As the voltage on the collector rises, it pulls the electrolytic up with it and since it is uncharged, the other lead is pulled up too.

This causes the base of the first transistor to be turned on hard and very soon we have a situation where both transistors are SATURATED.

The next point to understand is the voltage across the electrolytic under discussion. Its negative will be at .65v and its positive will be at about 2.4v. The electro has effectively been stretched between base and rail and its important to understand that the base voltage cannot rise above .65v.

The circuit sits in this condition while the electrolytic gradually charges a little more and this causes the base of the first transistor to turn off slightly.

This is passed to the second transistor which also begins to turn off.

In a short period of time the voltage on the collector falls slightly and this drop is transferred directly the first transistor via the electrolytic. Very soon we have a situation where the first transistor is turning the second off and the second is turning the first off. Both are now completely OFF and the 100k resistor takes over to start the process again.

Each time the circuit "cycles" the speaker produces a 'click' and since these clicks are produced in rapid succession, the result is a pleasant tone.

## CONSTRUCTING THE TESTER

All the components are mounted on a small PC board that is designed to fit into a toothbrush case. There are a number of suitable cases and even the small size will fit the board. At first we thought the soft type of case would not be suitable but after Paul tried it, we found it was the best. The soft plastic is more durable and will not fracture if dropped or bumped. The rigid styrene cases tended to crack very easily and one of ours was crushed under foot when it fell on the floor!

The case is the first item to purchase and it will give you a guide as to the maximum height allowable for the components. If some of the parts are too high, they can be bent over and it is important to know about this before you start.

Next you need to determine the type of switch you will be using. The board will take two sizes: a mini single pole double throw or a mini double pole double throw.

Depending on which one you intend to use, the appropriate holes must be drilled in the PC board.

Once this is done, the components can be mounted.

Start assembly at one end of the board and fit each part as you come to it. The mini speaker can be inserted either way around as it is not polarity sensitive but the LED, transistors, diodes and electrolytics must be fitted as shown. If you are not sure about the placement, don't guess, refer to data or get someone to assist you.

The probe is made from a paper clip that has been straightened at one end and bent into a hook at the other so that a strong solder connection can be made.

The two batteries are soldered to the board via short lengths of tinned copper wire. This will keep them firmly together and keep the whole assembly rigid.

The wander lead has either an alligator clip or E-Z clip attached and this allows it to be connected to one rail of the project under test so that the probe can be used to go over the rest of the board in the hunt for the fault.

When everything has been soldered in place, slide the switch ON and the LED will illuminate. Touch the two probes together and the oscillator will emit a tone.

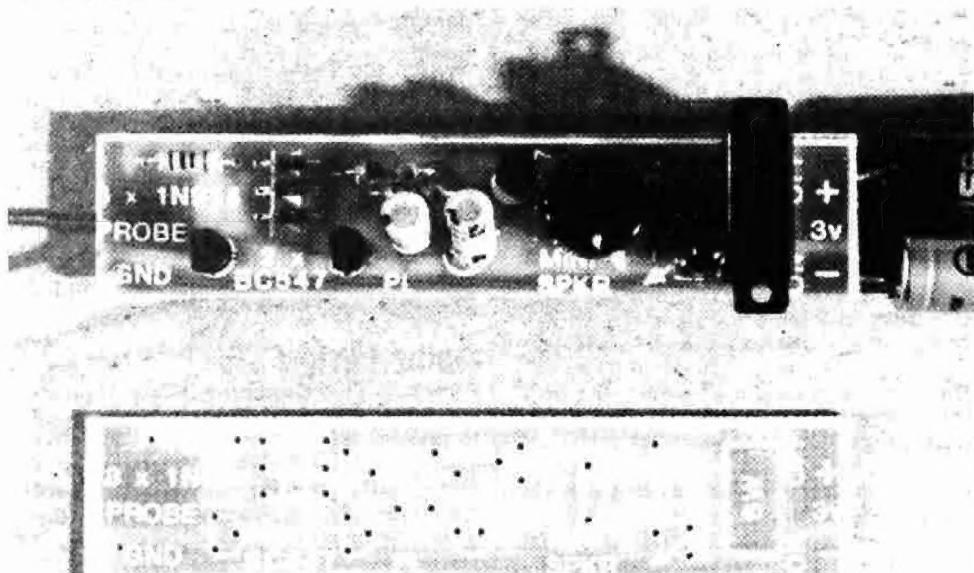
## TESTING THE UNIT

You will require a diode, 180R resistor and a 220R resistor.

Place the probes across the diode, firstly one way then the other. The tone should not be heard.

Place the probes across the 180R resistor. The tone should be emitted. Place the probes across the 220R resistor. The tone should not be emitted.

You may find the tester will operate on a resistor which is one value higher or lower than this. The actual value will depend on the battery voltage and the base-emitter junction voltage of the



A close-up of the Continuity Tester and PC board before the modification to the front end. See details of this modification on page 8.

The tester can be housed in a tooth-brush case and the soft-type cases are the best as they don't crack. It can then be added to our two other pieces of test equipment to make a very valuable trio for testing digital projects, especially processor designed projects, as these will be the products of the future.

gating transistor. But don't worry too much about the actual turn-on and turn-off values as most bus lines in computers have resistors of about 470R in their lines and the tester will not detect resistance values above 330R.

### IF IT DOESN'T WORK

If the Tester does not emit a tone when the two leads are touched together, follow these steps:

Remove the gating transistor (near the input probe) and turn the unit ON. This should allow the tone circuit to operate. If not, check the value of the 1k and 100k resistors and also their positions. Next check the 1uF electrolytics. Check also the BC 547 and BC 557 transistors. They cannot be swapped over. Finally check the speaker with a multimeter set to ohms to make sure it has continuity.

You can determine if the oscillator is jammed in the ON mode or OFF mode by taking a current reading across the switch. If the current is more than 20mA, it is jammed in the ON mode and this means the BC 547, in the oscillator, is conducting.

The transistor could be shorted between collector and emitter or the 1uF feedback electrolytic is open circuit.

Create a short between the base and emitter of the BC 547 to start the circuit into oscillation or replace the 1uF with 100n.

Remember, the mini speaker is a special 80R type and this value must be maintained for the circuit to work properly.

If the circuit is jammed in the OFF mode, either of the transistors in the oscillator may be open circuit or incorrectly fitted. Try new transistors.

If the circuit remains in the OFF state, remove the 1uF feedback electrolytic between the speaker and 100k and the circuit should turn ON.

If it does, the fault will lie in the electro being either a short circuit or very leaky.

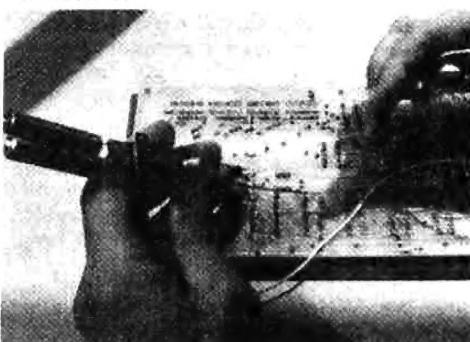
Once the tone circuit operates, the only other stage to be checked is the gating transistor.

If it fails to turn the tone off, the fault will lie in the base bias.

Check the voltage of the batteries. They should give at least .1v drop across the 100R resistor. If there is no voltage drop, check the voltage-dropping diodes. They should drop .65v each. Also check the supply voltage. It should be higher than 2.6v.

If the gating transistor still fails to turn the tone off, replace it. You may have damaged the base-emitter junction.

This should be sufficient to get the Tester working. If not ask another hobbyist to help you.



Using the continuity tester on the BUS lines of the TEC.

### HOW TO USE THE TESTER

The project you are going to test must be switched OFF and no part of it should have any voltages present.

This is because the input of the Tester connects directly to the base of a transistor and any voltage over .7v will destroy the junction.

Switch the Tester ON and the indicator LED will illuminate. Touch the two probes together and the tone will be emitted. This is the tone you will be listening for during the tests.

It is important to have a set plan of attack as lots of tests will be required for even the simplest of circuits and a logical approach will prevent you going over the same area twice or missing a test.

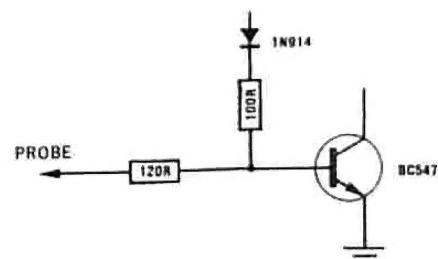
### MODIFICATION

After using the Continuity Tester for over 3 months, with total success, we decided to present it in TE.

Then Paul came up with a simple but clever modification that would allow the

probe to detect down to 47 ohms and also provide a safety feature for the first transistor.

It is simply the addition of a 120 ohm resistor between the base of the first transistor and the probe. Firstly this will act as a limiting resistor to prevent damaging the base of the transistor, should the probe be placed across power rails of a project when the voltage is present.



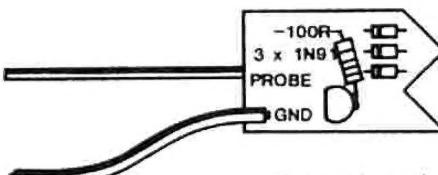
The 120R is added in series with the probe to protect the first transistor.

Secondly it reduces the input range so that the probe detects values from zero ohms to about 47 ohms.

Whereas we have been careful to turn off the supply to any project under investigation, the idea of directly connecting the base to the probe is not wise. It means any voltage above about .7v will have the capability of damaging the input transistor.

This mod overcomes the problem and makes it more robust in use.

The modification is carried out as follows:



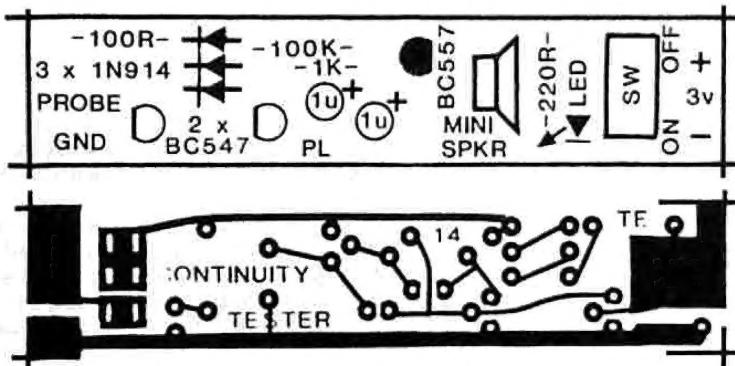
The mod on the front-end of the tester. The 120R is on the underside of the board.

Desolder the probe end of the 100R resistor and take it directly to the base of the transistor. Refer to the diagram for this. Cut the track between the base of the same transistor and the probe. Solder a 120R resistor between the base and the probe, either on the underside of the board or on top, so that it looks as neat as possible.

You may need to use a higher or lower value, according to the characteristics of your probe and experimenting will determine this.

This will make the probe relatively indestructible and I hope you find as much use for it as we have.

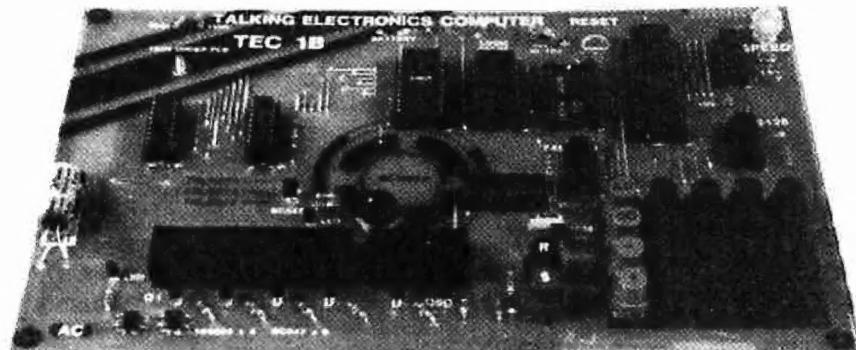
Quite honestly, it has found cracks and dry joints that the eye missed and has fixed at least 10 TEC's in the past 2 months. I'm sure you will like it.



# TEC-1A & 1B

## TALKING ELECTRONICS COMPUTER

Kit of parts: \$90.60  
PC Board: \$24.30  
Complete: \$114.90



TEC 1B with SHIFT KEY FITTED.

This is the fifth article on the TEC and quite frankly we have only just scratched the surface up to now.

The more ideas you try, the more you realise the potential of programming.

We have received a number of programmes for the 7-segment displays as well as the 8x8. These have been included in this article and also a few more hints on programming in general.

But before we get onto the programmes, there are a number of loose ends we have to tidy up, to bring the documentation up to date.

So far there have been 4 different models of the TEC and although the changes have been slight, they have not been put down on paper.

As far as the software is concerned, all models are compatible as the only modifications have been in the hardware.

The output latches have been changed from 8212's to 74LS273's, the 2200uF filter electrolytic changed to 1000uF and the 7805 mounted under the board so that its leads cannot be bent or broken.

The rest of the design remains substantially the same with the only addition being a shift button near the keyboard.

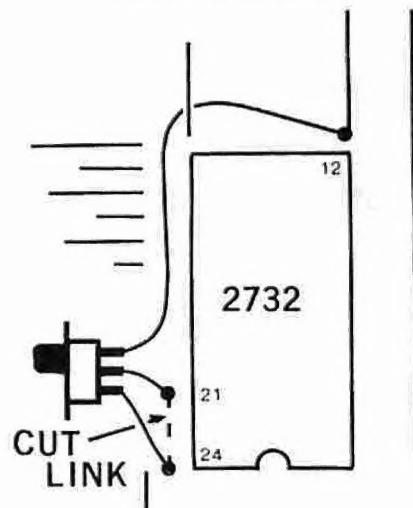
This button allows the keys to have a second function and we have already described these in issue 13.

TEC 1A's can be converted to TEC 1B's by adding a push button, a 47k resistor and a diode. When you update to MON 2, the SHIFT function allows INSERT and DELETE and a number of other commands.

### PART V

#### Features in this article:

- ★ Crystal Oscillator
- ★ Input/Output Module



When you want to access the MON 2 program, a switch must be fitted to the board so that pin 21 can be taken to ground. This will enable the lower half of the 2732 to be brought into the system and thus run the MON 2 listing.

The diagram above shows how to fit the mini slide switch to the two halves of the link that has been cut as shown.

You can switch from one monitor to the other at any time by pressing reset and altering the switch.

If you are writing a program using the MON 1B, it is best to start at 0900, so that when (if) you want to use the INSERT or DELETE functions, you can change to MON 2, use the function and then change back to MON 1B.

Gradually you will realise it is best to use MON 2 for most of your programs.

There are two major differences between MON 1B and MON 2. MON 1B uses a simple routine that places the value of a key directly into the accumulator, without firstly saving the value of the accumulator. Thus its original value is destroyed. MON 2 loads the key value into location 08E0 and thus your program must include an instruction that looks at this location for the value of the key.

Unless you load directly into the A register.

Simple programs designed for MON 1B will not run on MON 2 if they include a key press; unless they are altered accordingly.

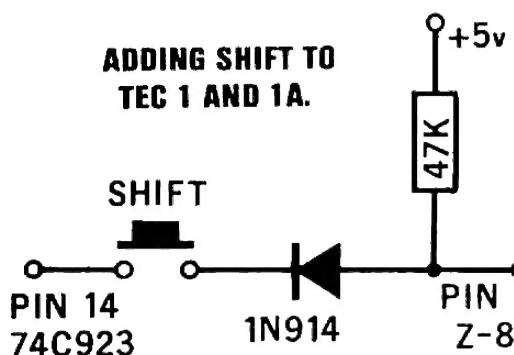
#### THE 2732 MONITOR

Both MON 1B and MON 2 are in the same chip and is called MON 1B/2. The MON 1B program has been placed in the upper half of memory so that when it is placed in the TEC, the MON 1B section will run and the computer will display 0800. You can now access all the games, tunes and running letter routines as covered in issues 10, 11, 12 and 13.

The MON 2 routine is more advanced and does not contain any of the games. Instead it has a SHIFT routine that enables you to insert bytes into a program by shifting all the higher bytes, and the byte at the present address, up one location. And a delete function, as well as a number of other routines that have been covered in issue 13.

The second difference is the start address for programming. MON 1B starts at 0800, while MON 2 starts at 0900. Programs written at 0800 cannot be successfully modified via the insert and delete functions as they will run into part of the scratchpad area for the MON 2 system.

The following diagram shows how to add the diode and resistor for the shift function. The diagram in issue 13 was not clear and this is an improvement:



#### TEC 1A/1B CONSTRUCTION HINTS:

The output latches for the latest TEC's are 74LS273's and the dotted link below each chip is fitted.

The 7805 regulator bolts directly under the PC board and a little thermal compound can be applied to assist heat transfer.

The small link from pin 4 of the 74LS138 IN/OUT decoder must be added. It can be cut later if expansion is required.

About 58 empty holes will be on the board after construction. Some provide for expansion while others are unused.

After the keys have been added and everything is operating satisfactorily, the letters and numbers can be applied to the tops.

Firstly clean the buttons with methylated spirits and apply the rub-down letters. Cover them with clear nail varnish to protect them. If you want to add another layer, wait for the first to dry, otherwise the letters will smudge!

#### NOTES ON THE 8x8 DISPLAY

The 8x8 has been modified to include sinking and sourcing transistors as described on P 27 of issue 12 and all kits now include 16 transistors and the necessary current limiting resistors.

This results in the LEDs being driven harder and increases the brightness of the display noticeably.

This is important when multiplexing as each LED will be turned on for only about one-eighth of the time and if sufficient current is supplied during this instant, the LED will appear to be on for the total period of time with an acceptable brightness.

We had an interesting fault in an 8x8 last week. It is interesting because the knowledge we gained applies to other projects where LEDs are driven in parallel.

A constructor built the 8x8 and was not happy with the output of about 3 of the LEDs.

He went to his local electronics shop and bought a few replacements.

After fitting them, he was quite surprised that they did not work at all! So he rang us. At this particular point in time we were not familiar with the fault and did not know how to advise him. So we suggested he call around with the project.

Some time later that day he arrived and we noticed the first difference was the colour of the LEDs he had used. They were less opaque than the rest and the crystal inside the LED could be readily seen. This did not disturb us as the light output of the LEDs was our prime concern.

When we tested it, sure enough; the 3 LEDs did not light up.

On measuring across the new LEDs with a multimeter set to low ohms, the voltage drop across the crystal was slightly higher than the rest. (When we are taking a measurement like this, the swing of the needle is being taken as a voltage drop. We are using the 3v supply in the multimeter to provide the LED with voltage and the needle tells us the characteristic voltage drop across the crystal.)

We then got three LEDs from our stock and measured the characteristic voltage drop. It was exactly the same as the majority in the display and when we fitted them, the whole screen lit up perfectly.

The reason why the LEDs failed to illuminate was due to the higher voltage needed to turn them on. Even if this is 100mV or so, the result will be the LED will not turn on at all. (See the experiment in Stage-1, P 9.)

It is important that LEDs are matched according to this characteristic voltage, for situations where they are placed in parallel. The 8x8 is one example as the LEDs are effectively in parallel when the whole screen is being illuminated in a non-multiplexed situation.

#### DISPLAYING LETTERS AND NUMBERS

The 7-segment display is quite a unique unit. It will display all the numbers from 0 to 9 as well as many of the letters of the alphabet.

There are only about seven letters that cannot be readily displayed and for these we will have to make a compromise.

The letter M is displayed as a small 'n', with a bar over the top. This corresponds to a feature in mathematics where a dot is placed over the first and last digits in a

number to indicate the number repeats. (This is called a recurring number or recurring fraction).

The letter W is displayed as a small 'u' with a bar over the top, for the same reason. The letter 'U' is displayed as a capital letter while V is a small 'u'.

The letter 'X' is displayed as part of a cross and Z is shown as two angles in opposite corners of the display, and looks quite readable.

The only letters which require interpretation are 'K' and 'Q'.

Ten other characters have also been included such as a question mark and 'equals' as well as a reverse bracket to assist in displaying mathematical problems.

A = 6F	? =	4D
B = E6	= =	54
C = C3	- =	04
D = EC	: =	38
E = C7	" =	10
F = 47	; =	0A
G = E3	r - - =	30
H = 6E	]- - =	20
I = 28	[ - - =	85
J = EB	L - - =	0F
K = 67	) =	
L = C2		
M = 65		
N = 6B		
O = EB		
P = 4F		
Q = 3F	1 =	28
R = 44	2 =	CD
S = A7	3 =	AD
T = 46	4 =	2E
U = EA	5 =	A7
V = E0	6 =	E7
W = E1	7 =	29
X = 26	8 =	EF
Y = AE	9 =	AF
Z = C9	0 =	EB

#### TESTING A BLANK 2716 FOR FF's

After erasing an EPROM, such as a 2716, it is wise to make sure it is entirely blank before reprogramming it. The program that follows does just that. It does not inform you of the location or locations that do not contain FF, but rather the screen goes blank and stays blank if a location has not been fully erased.

If all locations contain FF, the TEC resets via the MONitor program to the start-up address (either 0800 or 0900). This program can be placed anywhere in RAM and will work with either MON 1 or MON 2.

- by James Doran, 3218

```
11 00 08
21 00 10
7E
FE FF
20 07
23
1B
7A
B3
20 F5
C7
76
```

As promised, a larger photo of the robot arm. If you have built anything like this, why not take a photo and send it in.

Your ideas, combined with others, will help us to present an article.

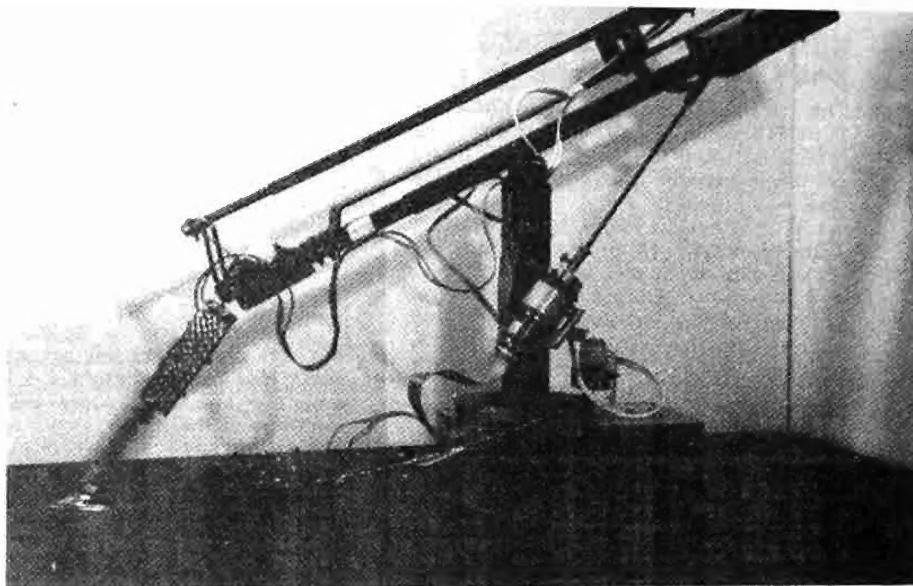
## MON 2 HEX LISTING:

For those with the TEC 1B and an EPROM BURNER, here is the hex listing for the MON 2.

With this you can make your own MON 2, and save the cost of conversion.

Insert the data **0800** on the TEC, and continue through to **0D64**.

Go through the program at least once, checking each of the values to make sure a mistake has not been made. A single mistake can mean the difference between perfection and failure.



## MON 2 HEX LISTING FOR TEC 1B:

0000 C3 00 02 FF	0114 1A 96 1C 8E	0228 FF FF FF FF	033C 01 06 20 10	0450 C3 7D 03 FF
0004 FF FF FF FF	0118 1E 86 20 7F	022C FF FF FF FF	0340 FE AF D3 01	0454 FF 57 21 DF
0008 1A C0 08 E9	011C 22 77 24 71	0230 FF FF FF FF	0344 C1 D1 E1 F1	0458 08 CB 9E CB
000C FF FF FF FF	0120 26 6A 28 64	0234 FF FF FF FF	0348 C9 FF FF FF	045C 66 20 08 01
0010 2A C2 08 E9	0124 2A 5F 2D 59	0238 FF FF FF FF	034C FF FF FF FF	0460 00 00 CD 90
0014 FF FF FF FF	0128 2F 54 32 50	023C FF FF FF FF	0450 21 80 00 1A	0464 04 CB E6 CD
0018 2A C4 08 E9	012C 35 4B 38 47	0240 31 C0 08 AF	0354 85 6F 7E 13	0468 B9 02 78 07
001C FF FF FF FF	0130 3C 43 3F 3F	0244 D3 01 D3 02	0358 21 DF 08 C9	046C 07 07 07 E6
0020 2A C6 08 E9	0134 43 3C 47 38	0248 21 B0 00 11	035C FF FF FF FF	0470 F5 79 07
0024 FF FF FF FF	0138 4B 35 50 32	024C D8 08 01 05	0360 F5 E5 21 E0	0474 07 07 07 E6
0028 2A C8 08 E9	013C 54 2F 59 2D	0250 00 ED B0 CD	0364 08 3E FF BE	0478 0F 83 47 79
002C FF FF FF FF	0140 5F 2A 64 28	0254 70 02 3E 08	0368 28 0E 7E E6	047C 07 07 07 07
0030 2A CA 08 E9	0144 6A 26 71 24	0258 CD 70 01 3E	036C 1F CB 6E 20	0480 E6 F0 82 4F
0034 FF FF FF FF	0148 77 22 7F 20	025C 0F CD 70 01	0370 01 C6 14 C3	0484 CD 90 04 CD
0038 2A CC 08 E9	014C 86 1E 8E 1C	0260 3E 01 32 DF	0374 A8 03 FF FF	0488 70 02 C3 7D
003C FF FF FF FF	0150 96 1A 94 19	0264 08 CD A0 02	0378 E1 F1 C9 FF	048C 03 FF FF FF
0040 FF FF FF FF	0154 A9 18 B3 16	0268 CD 60 03 18	037C FF E1 F1 C9	0490 F5 E5 21 D8
0044 FF FF FF FF	0158 BE 15 C9 14	026C FF FF FF FF	0380 FF FF FF FF	0494 08 78 E6 F0
0048 FF FF FF FF	015C D5 13 E1 12	0270 F5 E5 C5 CD	0384 CD 89 02 C5	0498 07 07 07 07
004C FF FF FF FF	0160 EF 11 FD 10	0274 89 02 E6 F0	0388 DD E1 DD 23	049C 77 23 78 E6
0050 FF FF FF FF	0164 FF FF FF FF	0278 0F 0F 0F 0F	038C DD E5 17 C	04A0 0F 77 23 79
0054 FF FF FF FF	0168 FF FF FF FF	027C 32 DC 08 0A	0390 FE 40 28 08	04A4 E0 F0 07 07
0058 FF FF FF FF	016C FF FF FF FF	0280 E6 0F 32 DD	0394 DD 7E 00 DD	04A8 07 07 77 23
005C FF FF FF FF	0170 C5 D5 E5 F5	0284 08 C1 E1 F1	0398 77 FF 18 EE	04AC 79 E6 0F 77
0060 FF FF FF FF	0174 A7 20 03 5F	0288 C9 21 D8 08	039C 3E 00 32 FF	04B0 E1 F1 C9 FF
0064 FF FF F5 DB	0178 18 02 1E 80	028C 7E 07 07 07	03A0 CD 70 02	04B4 FF FF FF FF
0068 00 31 E0 08	017C 21 00 01 87	0290 07 23 86 47	03A4 C3 78 03 FF	04B8 FF FF FF FF
006C F1 ED 45 FF	0180 85 6F 4E 23	0294 23 7E 07 07	03A8 C1 01 CD 70	04BC FF FF FF FF
0070 FF FF FF FF	0184 46 7B D3 01	0298 07 07 23 86	03AC 01 C3 21 04	04C0 21 DF 08 CB
0074 FF FF FF FF	0188 10 FE 46 AF	029C 4F 0A C9 FF	03B0 CD 89 02 0B	04C4 9E CB A6 FE
0078 FF FF FF FF	018C D3 01 10 FE	02A0 F5 E5 D5 C5	03B4 DD 21 FE 3F	04C8 10 CA E0 00
007C FF FF FF FF	0190 0D 20 F1 F1	02A3 11 D8 08 AF	03B8 DD 7E 00 DD	04CC FE 11 CA E6
0080 EB 28 CD AD	0194 E1 D1 C1 C9	02A8 D3 01 CD 50	03BC 77 01 DD 2B	04D0 00 FE 12 CA
0084 2E A7 E7 29	0198 FF FF FF FF	02AC 03 CB 4E 28	03C0 DD E5 E1 79	04D4 0C 03 FE 13
0088 EF 2F 6F E6	019C FF FF FF FF	02B0 01 Cb E7 D3	03C4 BD 20 F1 78	04D8 CA C0 01 FE
008C C3 EC C7 47	01A0 F5 E5 2A D6	02B4 02 3E 20 D3	03C8 BC 20 ED DD	04DC 14 CA 50 05
0090 E3 66 25 E8	01A4 08 7E FE FF	02B8 01 06 20 10	03CC 3E 01 02 CD	04E0 FE 15 CA FF
0094 4E C2 2D 6B	01A8 20 03 E1 F1	02BC FE AF D3 01	03D0 70 02 C3 78	04E4 FF FE 16 CA
0098 EB 4F 2F 4B	01AC C9 FE FE 28	02C0 CD 50 03 CB	03D4 03 FF FF FF	04E8 FF FF FE 17
009C A7 46 EA E0	01B0 F1 23 CD 70	02C4 28 02 CB	03D8 E5 F5 DD E5	04EC CA F1 01 FE
00A0 AC A4 AE C9	01B4 01 18 EE FF	02C8 E7 D3 02 3E	03DC C5 AF 32 DF	04F0 18 CA 70 05
00A4 10 08 18 04	01B8 FF FF FF FF	02CC 10 D3 01 06	03E0 08 06 06 21	04F4 FE 19 CA FF
00A8 1C 00 FF FF FF	01BC FF FF FF FF	02D0 20 10 FE AF	03E4 D8 08 3E 19	04F8 FF FE 1A CA
00AC FF FF FF FF	01C0 21 DF 08 CB	02D4 D3 01 CD 50	03E8 77 23 10 FC	04FC FF FF FE 1B
00B0 00 09 00 00	01C4 46 20 07 CB	02D8 03 CB 4E 28	03EC 2A D0 08 7E	0500 CA FF FF FE
00B4 FF FF FF FF	01C8 C6 CB 8E C3	02DC 02 CB E7 D3	03F0 FE FF 20 06	0504 1C CA 60 06
00B8 FF FF FF FF	01CC 78 03 CB 86	02E0 02 3E 08 D3	03F4 C1 DD E1 F1	0508 FE 1D CA FF
00BC FF FF FF FF	01D0 CB CE C3 78	02E4 01 06 20 10	03F8 E1 C9 FE FE	050C FF FE 1E CA
00C0 1B 18 1E 1D	01D4 03 FF FF FF	02E8 FE AF D3 01	03FC 28 EE DD 21	0510 FF FF FE 1F
00C4 12 17 0E 29	01D8 C5 06 80 CD	02EC CD 50 03 CB	0400 D8 08 06 05	0514 CA FF FF FE
00C8 0B 22 29 17	01DC A0 02 10 FB	02F0 4E 28 02 CB	0404 DD 7E 01 DD	0518 20 CA FF FF
00CC 12 0C 24 29	01E0 C1 C9 FF FF	02F4 E7 D3 02 3E	0408 77 00 DD 23	051C FE 21 CA FF
00D0 19 29 29 29	01E4 ED 4B D2 08	02F8 04 D3 01 06	040C 10 F6 7E 32	0520 FF FE 22 CA
00D4 FE 1C 1D 18	01E8 CD 90 04 CD	02FC 20 10 FE AF	0410 DD 08 23 06	0524 FF FF FE 23
00D8 17 0E FF FF	01EC 70 02 C3 78	0300 D3 01 00 C3	0414 40 CD A0 02	0528 CA FF FF FE
00DC FF FF FF FF	01F0 03 FF ED 4B	0304 18 03 FF FF	0418 10 FB 18 D3	052C 24 CA B0 03
00E0 CD 89 02 03	01F4 D4 08 CD 90	0308 FF FF FF FF	041C FF FF FF FF	0530 FE 25 CA 84
00E4 18 04 CD 89	01F8 04 CD 70 02	030C CD 89 02 C5	0420 FF D6 01 36	0534 03 FE 26 CA
00E8 02 0B CD 90	01FC C3 78 03 FF	0310 E1 31 C0 08	0424 FF CB 67 C2	0538 FF FF FE 17
00EC 04 CD 70 02	0200 ED 73 E8 08	0314 E9 FF FF FF	0428 C0 04 CB 6F	053C CA E4 01 C3
00F0 21 DF 08 CB	0204 31 00 09 F5	0318 CD 50 03 CB	042C C2 C0 04 21	0540 78 03 FF FF
00F4 C6 CB 8E C3	0208 C5 D5 E5 DD	031C 46 28 02 CB	0430 DF 08 CB 46	0544 FF FF FF FF
00F8 78 03 FF FF	020C E5 FD E5 08	0320 E7 D3 02 3E	0434 CA 55 04 57	0548 FF FF FF FF
00FC FF FF FF FF	0210 D9 F5 C5 D5	0324 02 D3 01 06	0438 FF D8 01 21	054C FF FF FF FF
0100 FD 10 10 FD	0214 E5 ED 57 F5	0328 20 10 FE AF	043C DF 08 CB 5E	0550 CD 89 02 60
0104 11 EF 12 E1	0218 AF 32 CC 08	032C D3 01 CD 50	0440 20 03 AF CB	0554 69 3A E1 08
0108 13 D5 14 C9	021C 32 CD 08 3E	0330 03 CB 46 28	0444 DE 07 07 07	0558 23 BE 20 FC
010C 15 BE 16 B3	0220 FF 32 E0 08	0334 02 CB E7 D3	0448 07 E6 F0 82	055C 44 4D CD 90
0110 18 A9 19 9F	0224 C3 40 02 FF	0338 02 3E 01 D3	044C 02 CD 70 02	0560 04 C3 53 02
			0564 FF FF FF FF	

## HOW THE CIRCUIT WORKS (and a general discussion.)

The circuit diagram is TALKING ELECTRONICS COMPUTER 1B (TEC 1B). It is a 9-chip, single-board computer capable of executing Machine Code commands and displaying the result on either the inbuilt display (a set of 7-segment displays) or on other displays via the expansion socket.

The expansion socket is configured identical to the RAM socket and is accessed via line Y2 of the ROM/RAM decoder 74LS138, at the top right-hand corner of the diagram.

The computer starts-up via a MONitor program contained in the 2732 and two monitor programs are in this chip.

The MON 1 select switch takes address line A11 LOW for the low half and HIGH for the upper half.

The other major change between TEC 1 and TEC 1B is the output latches. They were originally 8212's but now 74LS273's have been used. These are a modern chip and are more readily available.

### STARTING UP

When the power is applied to the computer, the reset line on the Z-80 is taken low for an instant via the 100n capacitor and this resets the internal workings of the Z-80.

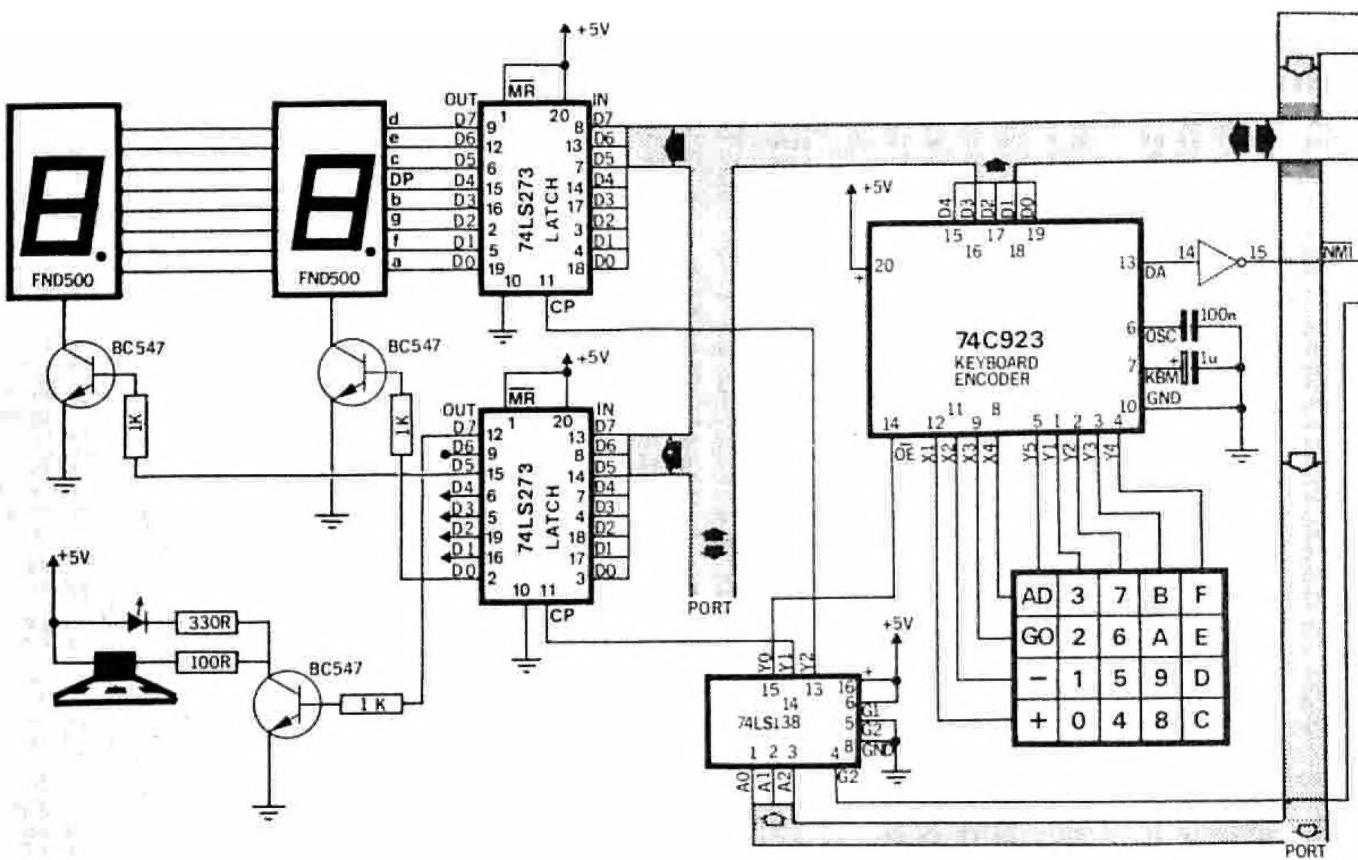
Its first operation is to look for the first byte of data at address zero, in the monitor. Depending on this being a one-

contains 11 lines while the data bus contains 8 lines. The data bus is always 8 bits wide for a Z-80 processor and this gives it the name '8-bit system'.

The address bus is a ONE-WAY bus in which the Z-80 activates the lines and turns them on and off using binary notation to generate an address value.

When all lines are LOW, address zero is represented. When line A0 is HIGH, address 1 is represented. The Z-80 has 16 address lines and address 1 is: 0000 0000 0000 0001. When line A1 is HIGH, address 2 is: 0000 0000 0000 0010.

The address lines connect to a number of chips but only one will respond due to a 'turn-on' line called a command line being required to be activated.



**TEC 1B COMPUTER CIRCUIT**

When the ROM select switch is HIGH, MON-1 program is accessed and the computer displays **0800**. When the switch is LOW, the computer displays **0900** and the MON 2 program operates.

This has been done so that the TEC 1B is compatible with the original TEC 1 and it can be upgraded by adding a monitor switch and a programmed 2732 EPROM.

The original TEC 1 had a 2716 EPROM but these chips are no longer manufactured and thus a 2732 is now used. When a 2732 is placed in a 2716 socket the upper half of the chip is accessed and thus MON 1 program has been placed in the upper half.

byte, two-byte or three-byte instruction, the Z-80 will execute it or request one or two more bytes.

The flow of information from the Z-80 to the other chips is via two buses. They are the **ADDRESS BUS** and **DATA BUS**. In addition, there is a set of control lines (sometimes referred to as the control bus) that activate (generally) one chip at a time.

All signals within the computer are at a level equal to rail voltage (called HIGH) or ground (called LOW). For this reason they are called digital circuits.

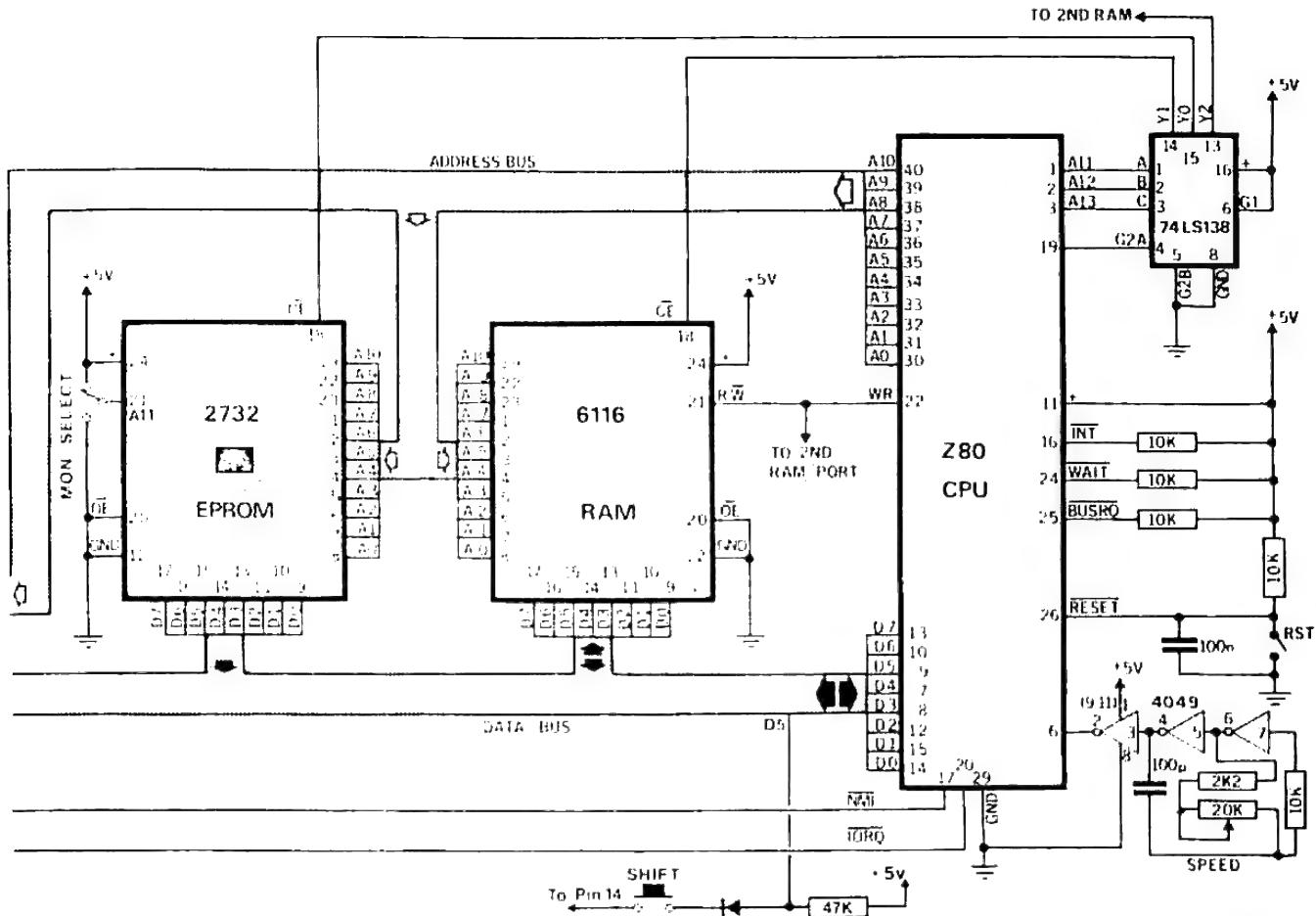
The shaded paths of the diagram represent buses and the address bus

These command lines are called chip select, chip enable or output enable and this allows only one chip to be activated at a time.

The chip select lines are the outputs of a decoder chip and this chip is 'turned on' by the Z-80 and only one of its outputs goes low at a time.

It is a 3-line to 8-line decoder and this means it has 3 input lines and depending on the HIGH-LOW values on these lines, one of the outputs will go low.

This is a form of expander so that a single line from the Z-80 (e.g. from pin 19 or 20) can control 8 devices.



The top right-hand decoder is called the ROM/RAM decoder and the lower left-hand, the IN/OUT decoder

The data from the monitor flows to the Central Processing Unit (the Z-80) along the data bus as 8 parallel bits of information AT THE SAME TIME

This is called a BYTE of information and can have 256 different possibilities. The Z-80 knows if the byte is data or instruction by the fact that it starts at address zero looking for an instruction byte. From there the program must follow correctly and this is the responsibility of the programmer

The data enters the Z-80 via a holding register (an instruction register) that is not available to the programmer and to keep the discussion simple, we consider the byte flows directly into the A register (called the accumulator). This is the only register capable of accepting information from the data bus. All other registers must be fed from the accumulator.

Data can also flow out of the Z-80 along the data bus and this bus is BI-DIRECTIONAL. The arrows on the bus show the direction of flow of information.

The keyboard is scanned by the 74C923 and this is called hardware scanning as the chip has inbuilt scanning circuits for a matrix of 20 keys.

When a key is pressed, a signal is generated at the Data Available pin and the Z-80 is notified via the Non-Maskable Interrupt line.

The Z-80 immediately ceases all processing and jumps to address 66 in the MONitor. Here it executes a short program and activates the input/output decoder to turn on the keyboard encoder. The encoder puts a 5-bit number on the data bus and this is stored for later use or operated upon, as required

When the shift button is pressed, and kept pressed while one of the keys is pressed, an extra bit is added to create a 6-bit number and thus an additional set of 20 commands can be created

The output latches are also controlled by the in/out decoder and the control line on each latch is called CP (clock pulse).

When these lines are taken LOW, then HIGH again, the data appearing on the input lines is latched into the chip and will appear on the output lines and will remain there.

This allows devices such as 7-segment displays, relays or globes etc. to be activated.

The 6116 RAM is RANDOM ACCESS MEMORY and as the name suggests, bytes of information can be placed anywhere in its matrix of cells. These bytes are generally data however programs can be stored and run in RAM and these are usually developmental programs.

Information stored in RAM will only be maintained as long as the power is applied as the flip flops storing the data will not hold their state when power is removed.

### 'ADD-ONS'

This computer is only a baby in the computer world however it does have the facility for expansion and already a number of 'add-ons' have been produced.

Possibly the most important add-on is the NON-Volatile RAM. This consists of a battery backed-up 6116, into which programs can be placed.

Other devices can be connected to the system via the expansion port and this includes an IN/OUT module, an OUTPUT module, a display module and a controller module (to come).

The clock oscillator is adjustable via a speed control pot and allows programs to be run at different speeds for assessment. If a real-time situation is required, a crystal oscillator can be fitted and this will allow time to be programmed accurately.

The main intention of this computer is to provide the starting point for an understanding into computer operations. For this reason, machine code programming has been employed. This means you will be able to create your own systems for such applications as controllers and timers for industry and home and be able to produce the project from the ground up, without requiring any external operating system.

## PROGRAMS FOR THE TEC DISPLAYS and a sound Program:

Here are three programs for the TEC and TEC displays. The effects that can be produced on a set of 7-segment displays is quite amazing. I thought we had run out of ideas and yet they still keep coming.

The first program is a Space Invaders sound effect using button 4 as the firing button. The other two programs use the displays.

### SPACE INVADERS 'SHOOTING'

*Philip Burns 2118*

Computer sounds and effects are always impressive, especially when we have control over them.

This program does just that.

It is a Space Invaders sound effect and you can control it via button 4.

The point to note with this program is the way the delay is increased by inserting a varying value into a delay loop. In the latter half of the program the OFF time is gradually increased by placing another varying value into a delay loop.

The resulting ON-OFF values outputted to the speaker produce the changing tone.

The program only accepts the press of button '4' (determined by **CP 04**) and by pressing this button repeatedly, a firing sound will be produced.

```

LD A,12    800  3E 12
LD I,A    802  ED 47
LD H,FF    804  26 FF
LD E,01    806  06 01
INC B     808  04
LD A,80    809  3E 80
OUT (01),A 80B  D3 01
CALL 0818  80D  CD 28 08
XOR A     810  AF
OUT (01),A 811  D3 02
CALL 0818  813  CD 28 08
LD A,I    816  ED 57
CP 04     818  FE 04
JP Z 0800  81A  CA 00 08
DEC H     81D  25
JP NZ 0808 81E  C2 08 08
CP 04     821  FE 04
JR NZ 0821 823  20 FC
JP 0800   825  C3 00 08

LD C,B    828  48
DEC C    829  0D
JR NZ 0829 82A  20 FD
RETURN   82C  C9

```

### THE BOX G.L. Dunt 3219.

This program is an extension of the techniques we have been discussing in issue 12, P 18, covering the control of two or more pixels at the same time.

It produces an interesting piece of animation in which a box with lid is displayed and moved across the screen in a 'chase scene'.

Again we won't say much about the effect, except to say that you can get quite involved with it and find it very easy to improve upon.

The program consists of 25 'frames' and each frame requires 4 bytes of the table to produce the necessary effects. Each time you increase the table (by 4 bytes) you must also increase the counter register by one (for each frame).

By using 4 bytes we gain the ability to control two pixels at the same time. If only one display is required, the two pairs of bytes will be identical.

LD IX 0840	0800	DD 21 40 08
LD D,10	0804	16 19
LD C,40	0806	0E 40
LD A(IX + 00)	0808	DD 7E 00
OUT (01),A	080B	D3 01
LD A(IX + 01)	080D	DD 7E 01
OUT (02),A	0810	D3 02
DJNZ	0812	10 FE
XOR A	0814	AF
OUT (02),A	0815	D3 02
LD A(IX + 02)	0817	DD 7E 02
OUT (01),A	081A	D3 01
LD A(IX + 03)	081C	DD 7E 03
OUT (02),A	081F	D3 02
DJNZ	0821	10 FE
DEC C	0823	0D
JR NZ 0808	0824	20 E2
INC IX	0826	DD 23
INC IX	0828	DD 23
INC IX	082A	DD 23
INC IX	082C	DD 23
DEC D	082E	15
JR NZ 0806	082F	20 D5
JP 0800	0831	C3 00 08

at 0840:

↓ 01	↓ 01	↓ 01	↓ 20
E4	E4	E4	E4
↓ 01	↓ 01	↓ 10	↓ 20
E4	E4	C4	E4
01	01	01	10
E8	E1	E0	E4
01	01	20	10
E8	E1	E0	E4
01	01	02	08
E4	01	E0	E4
01	02	20	08
E4	E0	E0	E4
01	01	04	04
E2	04	E0	E4
01	02	20	08
E2	E0	E0	E4
01	01	08	02
E4	08	E0	E4
01	02	20	08
E4	E0	E0	E4
01	01	10	01
E4	00	E0	E4
01	04	20	04
E4	A4	E0	E4
01	01	20	01
E2	00	E1	E0
01	08	20	02
E2	64	E1	04

### Halilovic's Piano:

This program has been designed by BOB Halilovic and gives a piano effect when one of the 20 keys is pressed. The notes have a pre-determined length, and this distinguishes it from the organ programs we have previously presented.



Data	0800	00
Data	0801	09
LD A,1F	0802	3E 1F
LD (0901),A	0804	32 01 09
CALL 01B0	0807	CD B0 01
HALT	080A	76
CP 10	080B	FE 10
JR NC	080D	30 07
ADD A,05	080F	C6 05
LD (0900),A	0811	32 00 09
JR 0807	08014	18 F1
SUB A,0F	0816	D6 0F
JR 0811	0818	18 F7

G Sheehan &  
D Svendsen 3175

### BOOMERANG

Boomerang is a program for the TEC displays. The effect you get is so clever that we are not going to spoil it by telling you what happens.

The only point we will mention is the composition of the byte table.

Each pass of the program uses two bytes from the table and the end of the program is detected by looking for address **0844**. Register L will be 44 at the end of the table.

By using the table two bytes at a time, we can specify the display we wish to access and the segment to be lit.

Also, using a byte table like this requires less program and fewer registers. It is one of the tricks of compact programming.

The delay at 0900 produces the speed of execution

Try altering and modifying the program and you will learn a lot about what each instruction does. You can also lengthen it by adding more frames. It'll be like creating your own cartoon.

LD HL,0820	0800	21 20 08
LD A(HL)	0803	7E
OUT (01),A	0804	D3 01
INC HL	0806	23
LD A,(HL)	0807	7E
OUT (02),A	0808	D3 02
INC HL	080A	23
CALL 0900	080B	CD 00 09
LD A,L	080E	7D
CP 44	080F	FE 44
JP NZ 0803	0811	C2 03 08
JP 0800	0814	C3 00 08

at 0820:

↓ 01	↓ 10	↓ 20
09	C0	6F
↓ 02	10	10
03	A0	EA
04	08	08
06	24	A7
08	04	04
0C	44	A7
10	02	02
09	C0	28
20	01	01
03	A0	C7

### Delay at 0900:

900	11 FF 0A
903	1B
904	7B
905	B2
906	C2 03 09
909	C9

## PROGRAMS FOR THE 8x8 DISPLAY:

The 8x8 has remained a popular 'add-on' and we still get requests for more programs for it. Here are some recent submissions:

If you have written a program equal to these, send it in for inclusion in the next issue:

### FAN OUT Mk III

*John Svendsen 3175*

FAN OUT Mk III produces symmetry on the displays and can be seen by the same byte being outputted to both ports 3 and 4. The end of the table is detected by looking at the value of L and starting again when it equals the address of the end of the table.

LD HL 0815	21 15 08
LD A(HL)	7E
OUT (03),A	D3 03
OUT (04),A	D3 04
INC HL	23
CALL 0900	CD 00 09
LD A,L	7D
CP 20	FE 20
JP NZ 0803	C2 03 08
JP 0800	C3 00 08

at 0815:

18	81
3C	C3
7E	E7
FF	FF
E7	7E
C3	3C

900	11 FF 0A
903	1B
904	7B
905	B2
906	C2 03 09
909	C9

### BOUNCING BALL AND ROLLING BALL.

*G.L. Dunt. 3219*

This program is an extension and improvement over the Bouncing Ball program in issue 12, P. 26.

If you look at P 26, you will notice the program is fairly long.

This is because it is necessary to specify the start address of the ball, each time it changes direction.

Much of the program is a repetition of similar or nearly similar codes and to reduce its length we need to look at any part(s) that repeat.

At first they may not be obvious but one can be found that starts at the base of a column, up the column, across to the next and down to the base again. The sequence ends with the LED jumping to the start of the next column.

If we repeat this 4 times, the whole of the board will be covered. This will reproduce

the effect as described on P. 26 of issue 12. Using the same technique, we can travel across the display and back again, to produce a weaving effect as the LED advances up the display. To complete the travel we need to move the LED from the top right hand corner to the lower left hand corner ready for the start of the next sequence.

By using efficient programming as covered in this program, we can produce twice the effect with about half the program.

Most of the reduction is done by defining the co-ordinates of the ball only once. This is done at the beginning of the program and from there the ball position is kept in the C and D registers. They act as the x and y values in co-ordinate geometry.

To move the LED across or up and down the screen, the C and D registers are rotated left or right. Each register contains only one bit and when this moves past the end of the register, it either "sits in the carry box" or passes it and enters the other end of the register. In either case the carry flag is affected and we look for this to let us know the end of the display has been reached.

As you can see, the LED is either "off the end of the board" or at the other side of the display, when the carry is detected and we must shift it back one location, ready for the next run. This way the LED appears to be darting back and forth from one side to the other, and we are not aware of the 'corrections' that take place.

LD C,01	0800	0E 01
LD E,01	0802	16 01
LD A,C	0804	79
OUT (03),A	0805	D3 03
LD A,D	0807	7A
OUT (04),A	0808	D3 04
CALL 0900	080A	CD 00 09
RLC D	080D	CB 02
JR NC 0807	080F	30 F6
RR D	0811	CB 1A
RLC C	0813	CB 01
LD A,C	0815	79
OUT (03),A	0816	D3 03
LD A,D	0818	7A
OUT (04),A	0819	D3 04
CALL 0900	081B	CD 00 09
RR D	081E	CB 1A
JR NC,0818	0820	30 F6
RL D	0822	CB 12
RLC C	0824	CB 01
JR NC,0804	0826	30 DC
RR C	0828	CB 09
LD A,D	082A	7A
OUT (04),A	082B	D3 04
LD A,C	082D	79
OUT (03),A	082E	D3 03
CALL 0900	0830	CD 00 09
RR C	0833	CB 09
JR NC,081D	0835	30 F6
RL C	0837	CB 11
RLC D	0839	CB 02
LD A,D	083B	7A
OUT (04),A	083C	D3 04
LD A,C	083E	79
OUT (03),A	083F	D3 03
CALL 0900	0841	CD 00 09
RLC C	0844	CB 01
JR NC,083E	0846	30 F6

CALL 0900	0848	CB 09
RLC D	084A	CB 02
JR NC,082A	084C	30 DC
RR C D	084E	CB 0A
RR C D	0850	CB 0A
LD A,D	0852	7A
OUT (04),A	0853	D3 04
CALL 0900	0855	CD 00 09
RR D	0858	CB 1A
JR NC,0852	085A	30 F6
RR C	085C	CB 09
LD A,C	085E	79
OUT (03),A	085F	D3 03
CALL 0900	0861	CD 00 09
RR C	0864	CB 09
JR NC,085E	0866	30 F6
JP 0800	0868	C3 00 08

RRC C	0848	CB 09
RLC D	084A	CB 02
JR NC,082A	084C	30 DC
RR C D	084E	CB 0A
RR C D	0850	CB 0A
LD A,D	0852	7A
OUT (04),A	0853	D3 04
CALL 0900	0855	CD 00 09
RR D	0858	CB 1A
JR NC,0852	085A	30 F6
RR C	085C	CB 09
LD A,C	085E	79
OUT (03),A	085F	D3 03
CALL 0900	0861	CD 00 09
RR C	0864	CB 09
JR NC,085E	0866	30 F6
JP 0800	0868	C3 00 08

At 0900:

LD HL,0BFF	21 FF 06
DEC HL	2B
LD A,L	7D
OR H	B4
JP NZ 0903	C2 03 09
Return	C9

### RAIN DROPS:

*Jim Robertson.*

This program produces a very effective pattern, similar to falling rain. The random number generator is the interesting part as it is very difficult to produce random numbers in a program that loops.

CALL Random Nos.	CD 00 0A
AND 07	E6 07
LD H,0B	0805
LD L,A	0807
RLC (HL)	0808
LD DE,0006	080A
CALL SCAN	080D
DEC DE	0810
LD A,D	0811
OR E	0812
JRNZ	0813
JR START	0815

at 0900:

### SCAN

LD HL 0B00	0900	21 00 0B
LD B,01	0903	06 01
LD A(HL)	0905	7E
OUT (03),A	0906	D3 03
LD A,B	0908	78
OUT (04),A	0909	D3 04
LD B,20	090B	06 20
DJNZ	090D	10 FE
INC HL	090F	23
LD B,A	0910	47
XOR A	0911	AF
OUT (04),A	0912	D3 04
RLC B	0914	CB 00
JR NC	0916	30 ED
RETURN	0918	C9

at 0A00:

### RANDOM NUMBERS:

LD A,R	0A00	ED 5F
LD B,A	0A02	47
LD A,R	0A03	ED 5F
RLA	0A05	17
LD R,A	0A06	ED 4F
DJNZ	0A08	10 FB
RETURN	0A0A	C9

# PHONE DIALLER

## TURNING THE TEC INTO A PHONE DIALLER

The following three or four pages examine the development of an idea. It is a Telephone Dialler capable of storing up to 30 or 40 names and phone numbers with a dialling facility and auto re-dial.

It is only a program of ideas as the output appears on a speaker in the form of tones.

Since this is a fairly ambitious concept, it has been divided into 3 sections. Each section describes a program that is complete in itself and increases in complexity with complete design in section 3.

The first program is fairly simple. It shows how to get figures from the keyboard and display them on the screen. The second contains two function buttons, C and E. The 'C' key clears the screen and 'E' indicates the end of a phone number.

The third program is much more complex. It has more features and is keeping track of more things.

Each program has been created from scratch as it is almost impossible to 'add onto' an existing program.

Type each of these programs into the TEC and study them. This way you will learn how they operate.

### PHONE DIALLER PROGRAM 1.

This program is limited to displaying 6 digits on the TEC screen as no scrolling feature is present. As the keys are pressed, the numbers fill the screen from left to right. When the screen is full, the capability of the program is reached.

The screen buffer is located at **0900** and the scan rate is determined by the value of B (at **082E** and **082F**). We can increase or reduce the scan rate by altering the value of B and by adjusting the TEC clock speed.

No other features are available in this program. The TEC must be reset and 'GO' pushed to clear the screen so that a new number can be keyed in.

This simple program shows how to get numbers from the keyboard and onto the screen.

The only instruction that will be unfamiliar is **JRNC**. It effectively divides the keyboard in two, allowing keys 0-9 to be accepted and A-F to be disregarded.

**JRNC** means Jump Relative if the Carry flag is NOT SET. When the previous instruction is a 'COMPARE', it is best to substitute the word 'BORROW' for carry, and the instruction will be much easier to understand. This is because the compare instruction subtracts the data byte from the accumulator and if a borrow is required, the carry flag is SET.

PHONE DIALLER - Part 1	
LD D, 08	0800
XOR A	0802 AF
LD HL, 0900	0803 21 00 09
LD (HL), A	0806 77
INC HL	0807 23
DEC D	0808 15
JR NZ	0809 20 FB
LD A,I ←	080B ED 57
CP 0A	080D FE 0A
JR NC	080F 30 12
LD DE 0880	0811 11 80 08
ADD A,E	0814 83
LD E,A	0815 5F
LD HL, 0900	0816 21 00 09
LD A,(HL)	0819 7E
CP 00	081A FE 00
JR Z ←	081C 28 03
INC HL	081E 23
JR	081F 18 FB
LD A(DE) ←	0821 1A
LD (HL), A	0822 77
LD A,FF	0823 3E FF
LD I,A	0825 ED 47
LD C,20	0827 0E 20
LD HL, 0900	0829 21 00 09
LD D,06	082C 16 06
LD B,00	082E 06 00
LD A(HL)	0830 7E
OUT (02),A	0831 D3 02
LD A,C	0833 79
OUT (01),A	0834 D3 01
RRC C	0836 CB 09
DJNZ	0838 10 FE
XOR A	083A AF
OUT (01),A	083B D3 01
INC HL	083D 23
DEC D	083E 15
JR NZ	083F 20 ED
JR	0841 C3 0B 08

The first 8 memory locations are cleared so that the program will come on with a blank screen. We need only 6 locations. The 7th location is explained in the text. Register A is zeroed and this value is inserted into **0900 - 0907** via the HL register being the pointer register.

The Index register contains the value of the key. Compare the accumulator with **0A**. Jump relative if the key is A or higher. Load DE with the start of the DISPLAY TABLE. Add **80** to the key value. Load the result back into E. DE will point to a table-byte. Load HL with the start of memory. Look for the first blank memory location by loading the value pointed to by HL into the accumulator and comparing with zero until a blank location is found.

When found load A with the byte pointed to by DE. Load the table value into the blank memory location. Change the value of the index register by loading it with FF so that we can detect the same or another button. Start the scan at the left hand end of the display. Load HL with start of memory. Load D with 06 for 6 loops of the program. Load B with delay value for turning ON each digit. Load the data at the first memory location into A. Output to the segment port. Load C into A. Output to the cathode port. Rotate register C right, to access the 2nd display. Create a short delay to display the digit. Zero A. Output to the cathode port to turn display OFF. Increment to the next location. Decrement the loop register. Jump to start of loop if D not zero. Jump to start of program if D zero and look for new key.

at **0880**:

EB  
28  
CD  
AD  
2E  
A7  
E7  
29  
EF  
AF

### PHONE DIALLER - Part 2

The second part of the Phone Dialler program uses a different approach. As we have said, each must start afresh as it is more difficult to adapt an existing program.

This program accepts a string of digits of any length and will remember them for recall after key **E** (for END) has been pressed.

The **C** button clears the display and can be pressed at any time. When the desired number has been entered, button **E** is pressed. The display is blanked and the numbers emerge from the right hand end of the display and shift across to the left. Three empty spaces are created before the numbers start again.

In our program, **CP 0A** causes the Z-80 to subtract **0A** from the accumulator (it will hold the value of the key). When any key below **A** is pressed, the subtraction operation creates a borrow and this sets the carry flag. If we push key **B**, the operation will be **B - A** and the answer will require a borrow. Thus the carry flag will be SET. If we go to the program, we can see the Z-80 will continue down the program and NOT JUMP as the instruction says: JUMP RELATIVE NO BORROW.

To fully understand these instructions you have to comprehend the double negative. For instance: I am NOT, NOT going to jump means I AM going to jump.

Type the program at **0800** and the display conversion table at **0880**.

Push RESET, GO and the displays will blank. Press any combination of keys and notice that only number keys respond.

Modify the value of B in the scan section to increase the scan rate.

Some ideas for experimenting include: scanning from the opposite direction, scanning only 5 displays, allowing letters to appear on the screen, and changing the output to a CODE, so that you can turn it into a CODE-BREAKING game.

This program introduces the concept of control keys and also the need for sub-routines for any sequence that is required more than once.

Programs increase in length as more and more housekeeping is called for. Housekeeping is looking for button presses or detecting the end of a sequence etc.

The prime requirement of the program is to keep the displays illuminated. This means we must be calling SCAN for most of the time and as you will see, the SCAN routine is a favourite place to put house-keeping.

If you want a key to be immediately responsive, it must be checked during the SCAN loop. To be more precise, it must be checked during the inner-most loop as this is the loop which is being run for most of the time.

Key the program into the TEC and run it. Try changing some of the locations and see the result. This is the best way to following what is happening, especially at specific locations.

## HOW THE PROGRAM WORKS

The program generates 2 memory areas. One is made up of 6 locations, from 0900 to 0905 and is called the DISPLAY BUFFER. The other is from 0907 onwards and is called MEMORY AREA.

The SCAN ROUTINE (at 0877) looks at the Display Buffer locations and outputs their value onto the displays.

The remainder of memory, starting at 0907 holds any number of digital as required and is open-ended.

One location, 0906, is left blank and its purpose will be explained later.

As each number is keyed in, it is stored in memory, from 0907 onwards, and the HL register pair keeps track of the next available location.

The number is also outputted onto the display but firstly a SHIFT ROUTINE is called. The function of this routine is to take the value corresponding to the left-hand digit and drop it out of the buffer zone. The second location is then transferred to the first, the third to the second etc until all the digits have been shifted one place to the left. This leaves an empty hole at the right-hand end of the display.

The way in which this empty space is generated is quite clever. The '00' in 0906 is shifted into the 6th buffer location.

The program then loads the present key value in the buffer zone, position six, and reverts to a scan situation in which it is looking for an 'end of number' via button E.

When this is detected, memory is incremented one location and E is inserted.

The displays are cleared and the program picks up the first digit at 0907 and places it in the 6th position of the buffer area.

The shift routine is called then the next memory value is placed in the 6th buffer location.

Before each new value is loaded into the buffer area, it is compared with 0E to detect the 'end of message.'

When E is detected, three blank locations are produced and the message starts again.

The CLEAR function is included in the SCAN routine. This has been done so that CLEAR can be detected instantly, as the display scan must be running at all times to keep the displays illuminated.

## DIALLER Part 2 listing:

### Main Program:

LD D,20	0800	16 20
CALL CLEAR	0802	CD 5B 08
LD HL,0907	0805	21 07 09
LD A,I	0808	ED 57
CP 0A	080A	FE 0A
JR NC,0820	080C	30 12
INC HL	080E	23
LD DE,08A5	080F	11 A5 08
ADD A,E	0812	83
LD E,A	0813	5F
CALL SHIFT	0814	CD 65 08
LD A,(DE)	0817	1A
LD (HL),A	0818	77
LD (0905),A	0819	32 05 09
LD A,FF	081C	3E FF
LD I,A	081E	ED 47
CP 0E	0820	FE 0E
LR Z,002A	0822	28 05
CALL SCAN	0824	CD 77 08
JR 0808	0827	18 DF
INC HL	0829	23
LD (HL),A	082A	77
LD D,06	082B	16 06
CALL CLEAR	082D	CD 5B 08
LD HL,0907	0830	21 07 09
LD A,(HL)	0833	7E
LD D,20	0834	16 20
INC HL	0836	23
CP 0E	0837	FE 0E
JR Z,0849	0839	28 0E
LD (0905),A	083B	32 05 09
CALL SCAN	083E	CD 77 08
DEC D	0841	15
JR NZ,083E	0842	20 FA
CALL SHIFT	0844	CD 65 08
JR 0833	0847	18 EA
LD E,02	0849	1E 02
LD D,20	084B	16 20
CALL SCAN	084D	CD 77 08
DEC D	0850	15
JR NZ,084D	0851	20 FA
CALL SHIFT	0853	CD 65 08
DEC E	0856	1D
JR NZ,084B	0857	20 F2
JR 0830	0859	18 D5

### Clear:

XOR A	085B	AF
LD HL,0900	085C	21 00 09
LD (HL),A	085F	77
INC HL	0860	23
DEC D	0861	15
JR NZ,085F	0862	20 FB
RETURN	0864	C9

## Shift:

LD B,07	0865	06 07
LD IX,08FF	0867	DD 21 FF 08
LD A,(IX + 01)	086B	DD 7E 01
LD (IX + 00),A	086E	DD 77 00
INC IX	0871	DD 23
DEC B	0873	05
JR NZ,086B	0874	20 F5
RETURN	0876	C9

## Scan:

PUSH HL	0877	E5
PUSH DE	0878	D5
LD C,20	0879	0E 20
LD HL,0900	087B	21 00 09
LD D,06	087E	16 06
LD B,80	0880	06 80
LD A,(HL)	0882	7E
OUT (02),A	0883	D3 02
LD A,C	0885	79
OUT (01),A	0886	D3 01
RRC C	0888	CB 09
DJNZ 088A	088A	10 FE
XOR A	088C	AF
OUT (01),A	088D	D3 01
INC HL	088F	23
LD A,I	0890	ED 57
CP 0C	0892	FE 0C
JR Z,089C	0894	28 06
DEC D	0896	15
JR NZ,0880	0897	20 E7
POP DE	0899	D1
POP HL	089A	E1
RETURN	089B	C9
POP DE	089C	D1
POP HL	089D	E1
LD A,FF	089E	3E FF
LD I,A	08A0	ED 47
JP 0800	08A2	C3 00 08

### at 08A5:

0	=	EB
1	=	28
2	=	CD
3	=	AD
4	=	2E
5	=	A7
6	=	E7
7	=	29
8	=	EF
9	=	AF
0	=	

## PHONE DIALLER - Part 3

The third and final part of the Phone Dialler program is the longest and most impressive. It looks complicated because it is looking after a lot of things.

The program accesses memory and when using the 2k onboard RAM, it is capable of holding up to 36 names and numbers, each fitting into a block of memory 20H bytes long. The program allows up to 27 characters for the name and number and this should be sufficient for any situation.

The program uses a lot of sub-routines and they perform most of the work.

As the processor goes through the MAIN program, it CALLS the sub-routines and they do all the displaying, shifting, display converting etc.

Any operation that is required more than once is put into the form of a sub-routine. This reduces the length of the program and allows the sub-routines to be called as many times as required.

### USING THE PROGRAM

Basically the program is self explanatory as the instructions for its use are displayed on the screen after the GO button is pressed.

The first instruction is to select an INDEX NUMBER from 00 to 36 (decimal) into which the telephone number is placed.

Push button E and the screen will blank so that the index number can be inserted.

The index number will remain on the screen for about one second and then the second set of instructions will appear. After reading the instructions, push E. This will cause the screen to blank so that you can type the name corresponding to the phone number.

After the end of the name, insert a space by typing F and the program will convert to displaying a digit for each key pressed.

At the end of the phone number type E and the program will scroll the contents of memory.

To dial the phone number push D. The program will pause for 5 seconds then dial the number.

At the completion of dialling, the screen will scroll the name and number again.

You can redial the same number at any time by pressing D.

To re-load the memory BLOCK, push C. This will re-start the program and allow a new name and number to be inserted.

Once a name and number has been inserted into memory at a particular index value, it can be dialled very quickly. You can push either button C or RESET. If the Reset button is pushed, the GO button must be pushed for the first set of instructions to appear.

Push E and insert the index number; then push D. The computer will dial the number. A constant beeping will indicate the location is not filled and you should try another index.

At the end of dialling, the name and number will scroll and you can confirm it to be correct.

### A SUMMARY OF THE PROGRAM

The program creates a display buffer area at **0A80** to **0A85** and the values placed at these 6 locations are directly transferred to the TEC display via the SCAN routine.

The CLEAR routine zeros each of these locations and also the next location. This is one of the clever tricks of the program, and it is cleared for the following reason:

The SHIFT routine starts at a location that is one lower than **0A80**, (namely **0A7F**) and places the data at **0A80** into

## PHONE DIALLER PROGRAM:

```

CALL CLEAR
LD HL,0A0C ←
CALL SCROLL
CP 10
JR Z,0803 ←
CP 0A
JR C,0800
CALL CLEAR
LD A,FF
LD I,A
LD HL,0000
LD A,01
LD (09FE),A
CALL KEY VALUE
LD A,C
LD (09FC),A
LD A,01
LD (09FE),A
CALL KEY VALUE
LD A,(09FC)
RLA
RLA
RLA
ADD A,C
LD (09FC),A
LD D,20
CALL SCAN
DEC D
JR NZ,083C
CALL CLEAR
LD HL,0A1C ←
CALL SCROLL
LD A,(HL)
CP 10
JR Z,0845 ←
CP 0A
JR C,0842
CALL CLEAR
CALL MEM ADDR
LD D,1C
LD E,00
LD A,FE ←
LD I,A
CALL SCAN 2←
LD A,I
CP 10
JR NC,0861 ←
INC E
LD A,E
CP 02
JR Z,087C ←
LD A,I
CP 0F
JR Z,0895 ←
LD (09FA),A
JR 085E ←
CALL SHIFT ←
LD A,(09FA)
RLA
RLA
RLA
LD B,A
LD A,I
ADD A,B
LD (HL),A
LD (0A85),A
INC HL
DEC D
JR NZ,085C
JP 0800
XOR A ←
LD (HL),A
CALL SHIFT
LD A,D
LD (09FE),A
CALL KEY VALUE
LD B,03
INC HL
XOR A
LD (HL),A
DEC B
JR NZ,08A3
INC HL
LD A,10
LD (HL),A
NOP

```

```

0800 CD 20 09
0803 21 0C 0A
0806 CD C0 09
0809 FE 10
080B 28 F6
080D FE 0A
080F 38 EF
0811 CD 20 09
0814 3E FF
0816 ED 47
0818 21 00 00
081B 3E 01
081D 32 FE 09
CD 30 09
0823 79
0824 32 FC 09
0827 3E 01
0829 32 FE 09
082C CD 30 09
082F 3A FC 09
0832 17
0833 17
0834 17
0835 17
0836 81
0837 32 FC 09
083A 16 20
CD 80 09
083C 15
083F 20 FA
0840 CD 20 09
0842 21 2C 0A
0845 CD C0 09
084D 7E
084C FE 10
084E 28 F5
0850 FE 0A
0852 38 EE
0854 CD 20 09
0857 CD 60 09
085A 16 1C
085C 1E 00
085E 3E FF
0860 ED 47
0862 CD D0 0A
0865 2D 00
0867 FE 10
0869 30 F7
086B 1C
086C 7B
086D FE 02
086F 28 0B
0871 ED 57
0873 FE 0F
0875 28 1E
0877 32 FA 09
087A 18 E1
087C CD E1 09
087F 3A FA 09
0882 17
0883 17
0884 17
0885 17
0886 47
0887 ED 57
0889 80
088A 77
088B 32 85 0A
088E 23
088F 15
0890 20 CA
C3 00 08
0895 AF
0896 77
CD E1 09
0897 7A
0898 32 FE 09
089E CD 30 09
08A1 06 03
08A3 23
08A4 AF
08A5 77
08A6 05
08A7 20 FA
08A9 23
08AA 3E 10
08AC 77
08AD 00

```

The first 7 lines of the program displays "Enter Index etc and looks for the value 10 at the end of the table to repeat the sequence. The program also looks for an input value above 9 to jump out of the loop

The screen is cleared and the index register is loaded with FF so that we can detect when a button has been pushed.

Memory is set to zero by loading HL with 00 00. Location 09FE stores the value 01 so that key values called once. The requirement of the next 12 lines is to get a double decimal number into location 09FC. C will contain the key value and this is loaded into memory location 09FC (first figure). Repeat the sequence and call KEY VALUE once more

Load the first figure into A and rotate the accumulator 4 places to the left to shift the number into the upper half of the register

Add the second figure to the accumulator and store the result into 09FC as a two figure decimal number. Create a delay with register D and call SCAN for 20H loops (32 loops)

Clear the display and load the pointer register with the start address of the second table. Display "Enter name etc". Look for the end of the table (10) and loop, unless a key 0-9 has been pressed

Call CLEAR to clear the display  
Read MEMORY ADDRESS notes  
Register D counts up to 28 characters (max allowed).  
Register E counts to 2. Two key presses for a char  
Fill the I register via the accumulator so that we can detect when a key is pressed  
Scan the display looking for a key press 0-F

Increment the E register  
Load E into A  
Compare the accumulator with 02 and jump if the two are the same. If not go to the next instruction  
Look to see if a space is required as this will indicate the end of names and the beginning of numbers  
Jump relative if F has been pressed  
Store the value of A at 09FA and loop for second press of button  
Call SHIFT to get display ready for next number  
Load the first number into the accumulator and shift it 4 places to the left to occupy the upper half of the register

Save the result in B  
Put second number into the accumulator  
Combine the two to create a 2-digit number  
Load this value into the location looked at by HL  
Also load it into the first display location  
Increment HL  
Decrement D and  
Jump if 1C locations not filled  
Jump to start if overflow occurs  
Zero A and load it into the location looked at by HL to create a space  
Shift the display digits one place to the left  
Load the remaining locations into A and store at 09FE for use by the CALL KEY routine  
Call KEY VALUE. This will put NOS onto the display  
Create 3 blank locations after 10 numbers have been inserted, to produce a space between the end of the message and the start so that it can be scrolled across the display

Increment HL and load last location with 10 so that program will loop name and telephone number

this lower location. As can be seen from the program, this lower location is not displayed on the TEC and thus the data shifts off the screen. The data for the second location is shifted to the location for the first display and this repeats for the 6 locations. The result is the data in the blank location at **0A86** is shifted into the last display location and thus an empty space is produced on the display.

It is important for **0A86** to be empty for this to work.

The MEMORY ADDRESS routine creates areas that are 20H bytes long and starts at **0B00**.

The program stores the Index number at location **09FC** and as each memory area is created, it decrements the Index number and the program exits when the count register is zero.

The HL register will contain the start of this address. It is not used for any other purpose and thus it will not be destroyed during the running of the program and will hold the current value for re-dial, if required.

The SCROLL routine picks up the first byte from the table and places it at **0A85** and then calls SCAN for 20H loops (32 passes of the display).

The SHIFT routine is then called and all the bytes (including the blank locations) are transferred one position to the left.

The scroll program then loops and repeats the sequence until the end of the table is reached. It detects this by looking for 10H (we could have chosen any value) and the message re-starts.

When the 'Dial key' '**D**' is pressed, a BEEP routine and PAUSE routine are called. These produce a suitable ON-OFF tone to the speaker and the program converts the values in memory to a string of beeps.

The program ignores the name at the beginning of memory and looks for the first location containing zero.

The end of the phone number is detected by also looking for a location containing zero.

The program then jumps back to calling the start of memory and scrolls the message across the screen.

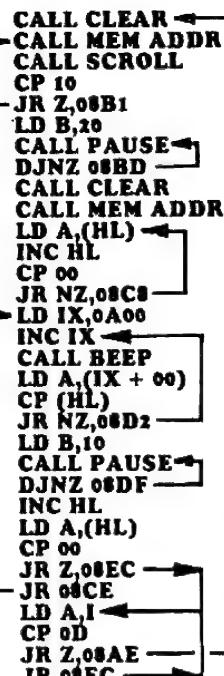
## SUGGESTIONS

The program can be keyed into the TEC and fills about 3 pages, from **0800** to **0AEE**.

After this is done, it is wise to save a copy of the program in non-volatile RAM so that it is not lost.

To save the program, type the following dump routine at **0F80**:

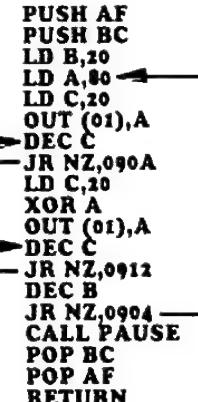
```
11 00 10
21 00 08
01 90 07
ED B0
C7
```



08AE	CD 20 09
08B1	CD 60 09
08B4	CD C0 09
08B7	FE 10
08B9	28 F6
08BB	04 20
08BD	CD 72 09
08C0	10 FB
08C2	CD 20 09
08C5	CD 60 09
08C8	7E
08C9	23
08CA	FE 00
08CC	20 FA
08CE	DD 21 00 0A
08D2	DD 23
08D4	CD 00 09
08D7	DD 7E 00
08DA	BE
08DB	20 F5
08DD	06 10
08DE	CD 72 09
08E1	10 FB
08E4	23
08E5	7E
08E6	FE 00
08E8	28 02
08EA	18 E2
08EC	ED 57
08EE	FE 0D
08F0	28 BC
08F2	18 F8

Clear the screen.  
Get start of BLOCK via **09FC** (36 blocks available).  
Scroll name and number across screen.  
Look for end of message. If another key is pressed, jump out of loop.  
Create a pause before dialling by loading B with 20 and calling pause 32 times. This creates approx 2 second delay.  
Clear the screen of any junk etc.  
Get start of block (00-36).  
Look for space between name and phone number by comparing the contents of each location with 00 and incrementing until 00 is found.  
The next 6 lines create the dialling pulses by loading IX with the start of the number table and calling BEEP routine. (The beep calls a pause). The program then compares the byte in the table with the byte in the block and loops until a comparison is found. Note: we go into the routine 'blind' and beep before a CPI!  
Create a short pause at the end of each digit so that the phone system detects the end of digit.  
Increment to next digit, look to see if end of phone number has been reached and return to above routine for next set of pulses.

## BEEP



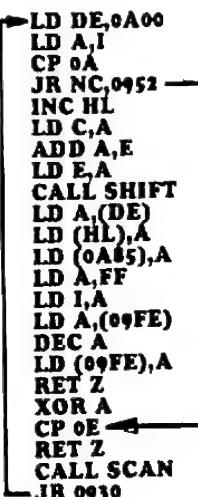
0900	F5
0901	C5
0902	06 20
0904	3E 80
0906	0E 20
0908	D3 01
090A	0D
090B	20 FD
090D	0E 20
090F	AF
0910	D3 01
0912	0D
0913	20 FD
0915	05
0916	20 EC
0918	CD 72 09
091B	C1
091C	F1
091D	C9

## CLEAR



0920	16 07
0922	AF
0923	21 80 0A
0926	77
0927	23
0928	15
0929	20 FB
092B	C9

## KEY VALUE



0930	11 00 0A
0933	ED 57
0935	FE 0A
0937	30 19
0939	23
093A	4F
093B	83
093C	5F
093D	CD E1 09
0940	1A
0941	77
0942	32 85 0A
0945	3E FF
0947	ED 47
0949	3A FE 09
094C	3D
094D	32 FE 09
0950	C8
0951	AF
0952	FE 0E
0954	C8
0955	CD 80 09
0958	18 D6

This routine clears the 6 display locations **0A80** to **0A85** and also **0A86** by zeroing A and loading HL with start address of buffer zone and loading zero into the location pointed to by HL. INC HL  
DEC D  
and jump for 7 loops.  
Return to main program.

Load DE to point to beginning of number table.  
Load key value into accumulator.  
Compare with 0A and jump if the key value is A-F or not pressed or go to next instruction if 0-9.  
INC HL (used when creating phone number)  
Save A in C.  
ADD the start of table to A [table may start at 0A03].  
Make DE ready to point at value in table.  
SHIFT display contents one place to left.  
Load byte from number table into accumulator.  
Load number byte into location in BLOCK.  
and also into right hand display.  
Load A with FF and then into I to detect when another key has been pressed.  
**09FE** contains 01 via beginning of of main program and KEY VALUE is called once. Or **09FE** contains 1C to keep track on the number of locations being filled in the BLOCK.  
Zero A.  
Compare accumulator with E and RETURN if E key is pushed. Otherwise call SCAN and display the contents of the 6 memory locations. Jump to stat of KEY VALUE sub-routine and loop until 0-9 pressed.

Decrement to **0F80** and push GO. Make sure the non-volatile RAM switch is on RAM (read/write) so that the data will be accepted. Check that the program has been dumped by addressing **1000** and compare the data with the listing.

If you have inserted names and numbers into index locations and want to save them, address **0F80** and push GO. Make sure the RAM card is in read/write mode and everything will be saved.

Switch to ROM mode and everything will be preserved.

You can now turn the TEC off.

To transfer the program back to **0800**, address **1780** and change 2 of the bytes to the following:

**11 00 08** ← these two bytes  
**21 00 10** ← are changed  
**01 90 07**  
**ED B0**  
**C7**

Decrement to **1780** and push GO. The RAM card should be in ROM MODE for this operation.

Push GO again and the program will run.

All names and numbers will be available.

#### AUTO REDIAL

An automatic re-dial facility can also be included so that the number automatically re-dials after say 5 or 10 minutes; if the number was originally engaged. This is very handy for those occasions when you particularly want to contact a person and their number is busy. By the time you get around to calling again, they have gone!

A simple addition to the program can be fitted in at **08BE** and this will create a delay by counting the number of times the name and phone number scroll past the display. This is only a suggestion and we have not actually produced the program for re-dial.

Register E is the 'count register' and the remainder of the program remains the same. The only bytes you will have to change are jump relative values as well as the jump value at **09B4**. You may also need a subroutine and a flag to pick up redial mode.

Here is a suggested AUTO RE-DIAL program for insertion at **08B4**:

```
LD E,40
DEC E
JR Z
CALL CLEAR
CALL MEMORY ADDR
CALL SCROLL
CP 10
JR Z
CALL CLEAR
```

#### MEMORY ADDRESS

LD HL,0B00	0960	21 00 0B
LD A,(09FC)	0963	3A FC 09
LD D,20	0966	16 20
CP 00	0968	FE 00
RET Z	096A	C8
INC HL	096B	23
DEC D	096C	15
JR NZ,096B	096D	20 FC
DEC A	096F	3D
JR 0966	0970	18 F4

#### PAUSE

XOR A	0972	AF
OUT (01),A	0973	D3 01
LD DE,02FF	0975	11 FF 02
DEC DE	0978	1B
LD A,E	0979	7B
OR D	097A	B2
JR NZ,0978	097B	20 FB
RETURN	097D	C9

#### SCAN 1

PUSH HL	0980	E5
PUSH DE	0981	D5
LD C,20	0982	0E 20
LD HL,0A80	0984	21 80 0A
LD D,06	0987	16 06
LD B,20	0989	06 20
LD A,(HL)	098B	7E
OUT (02),A	098C	D3 02
LD A,C	098E	79
OUT (01),A	098F	D3 01
RRC C	0991	CB 09
DJNZ 0993	0993	10 FE
XOR A	0995	AF
OUT (01),A	0996	D3 01
INC HL	0998	23
LD A,I	0999	ED 57
CP 0C	099B	FE 0C
JR Z,09A9	099D	28 0A
CP 0D	099F	FE 0D
JR Z,09B1	09A1	28 0F
DEC D	09A3	15
JR NZ,09B9	09A4	20 E3
POP DE	09A6	D1
POP HL	09A7	E1
RETURN	09A8	C9
POP DE	09A9	D1
POP HL	09AA	E1
LD A,FF	09AB	3E FF
LD I,A	09AD	ED 47
JP 0800	09AF	C3 00 0B
POP DE	09B2	D1
POP HL	09B3	E1
JP 08BB	09B4	C3 BB 0B

#### SCAN 2

PUSH HL	0AD0	E5
PUSH DE	0AD1	D5
LD C,20	0AD2	0E 20
LD HL,0A80	0AD4	21 80 0A
LD D,06	0AD7	16 06
LD B,20	0AD9	06 20
LD A,(HL)	0ADB	7E
OUT (02),A	0ADC	D3 02
LD A,C	0ADE	79
OUT (01),A	0ADF	D3 01
RRC C	0AE1	CB 09
DJNZ 0AE3	0AE3	10 FE
XOR A	0AE5	AF
OUT (01),A	0AE6	D3 01
INC HL	0AE8	23
DEC D	0AE9	15
JR NZ,0AD9	0AEA	20 ED
POP DE	0AEC	D1
POP HL	0AED	E1
RETURN	0AEE	C9

**Memory Address** sub-routine locates the beginning of the name and phone number block. Each block is 20H bytes long (32 bytes) and memory starts at **0B00**. The **BLOCK No** is stored at **09FC** and the program increments 20H loops for each block by decrementing register D to zero, then decrementing register A by ONE. This is repeated until A is zero. The sub-routine then exits. HL pair is constantly incremented during this program and will point to the start of the block we want.

**Pause** produces a silence from the speaker by outputting zero to port 01. Register DE is decremented and wastes computer time for about 1/10th second. This sub-routine then returns to where it has been called.

The **SCAN** routine uses H, L and D registers and thus they must be pushed onto the stack and saved. Load HL with start of display buffer. The routine displays 6 locations. The left hand display is accessed via line 20. Load B with a short delay value. Load the byte at the first location into A. Output to port D2. Load C into A and output to port D1. Zero A and output to port D1. Look at next memory location. Load the keyboard value into A. Look to see if CLEAR has been pressed. Jump if it has. DEC D ready for outputting to the next display. Jump relative if D is not zero. Pop DE and HL register pairs off the stack.

and RETURN to the main program. If CLEAR has been pressed, pop DE and HL and load the I register with **FF** so that the program will detect when another key has been pressed.

Jump to **0800**. POP DE and HL and jump to **08BB** if D (DIALS) has been pressed.

**SCAN 2** is identical to **SCAN 1** in the scanning section. The only difference is the checking instructions. To see if a particular key is pressed **SCAN 1** above checks to see if a function key is pressed, whereas **SCAN 2** performs the scan without any checks.

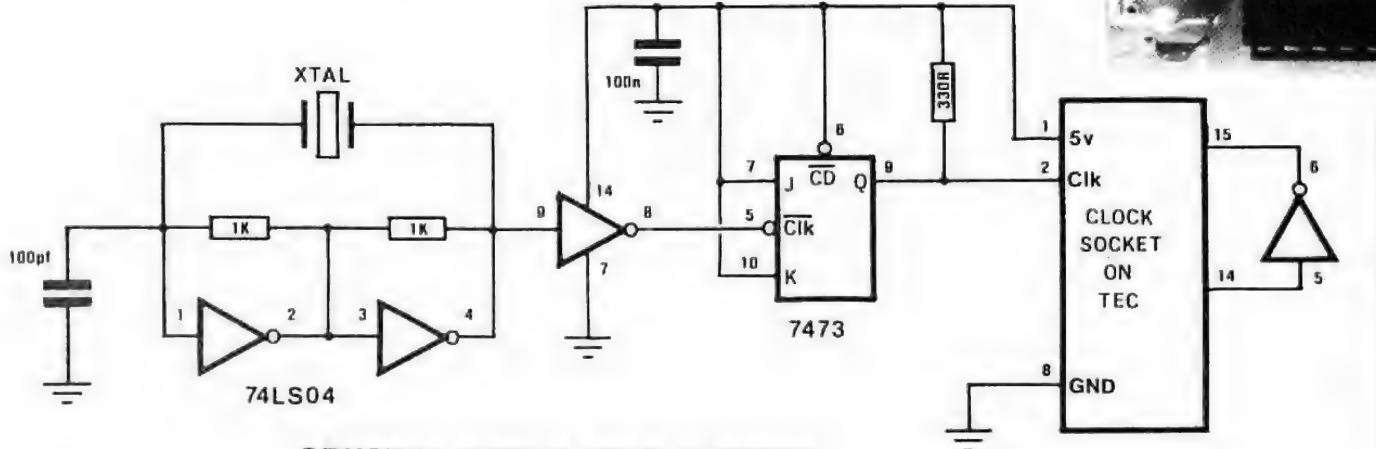
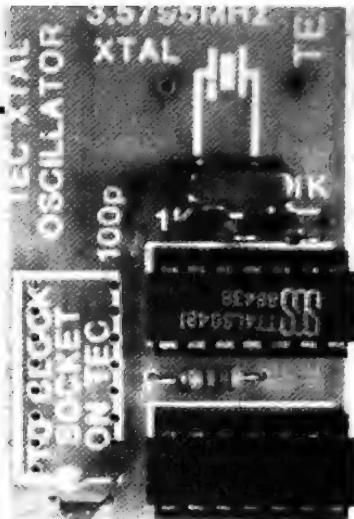
By careful programming both routines could be incorporated into one. This would require a 'check bit' and if set, the sub-routine would check the function keys.

Cont. P.51:

# CRYSTAL OSCILLATOR

#### **CONVERTS THE TEC TO REAL-TIME CAPABILITY**

**Kit of parts: \$9.85  
PC Board: \$2.10  
Complete: \$11.95**



## **CRYSTAL OSCILLATOR CIRCUIT**

This project is a crystal oscillator for the TEC. It turns the TEC into a fixed-frequency computer in which each of the Machine Codes takes up a precise period of time.

This means programs such as controller programs or timing programs will run for a precise time span and will not vary from one day to the next due to speed control adjustments.

As you know, the TEC was originally designed with an adjustable clock and its frequency could be altered by turning the speed control.

This served a valuable purpose as the games of skill (contained in the MONitor ROM) could be adjusted according to the skill of the player.

It also proved that the Z-80 could be run at very low speeds and even adjusted while operating and still execute the programs correctly.

The only disadvantage of a variable speed control is its inability to create accurate REAL-TIME programs.

This is highlighted by the clock program (as presented in issue 12). Everyone expects a clock to keep accurate time as even 'two dollar' watches are accurate to two seconds a month. The clock program could only approach this accuracy as it had to be manually adjusted via the speed control.

To remedy this situation Paul has produced a crystal oscillator module that plugs into the 4049 socket.

It contains an inverter chip (74LS04) and a divider chip so that a 4MHz crystal or colour-burst (3.5795MHz) can be used (because they are cheap) and a divider chip (7473) to divide the frequency by two so that the TEC will run at about the maximum speed permissible for a Z-80 CPU.

The 7473 is wired in TOGGLE mode to provide a divide-by-two output.

Some of the earlier model TEC's used a Z-80 CPU (later models used a Z-80A as these were cheaper than the Z-80!!) and the maximum operating speed for a Z-80 is about 2.5MHz.

Almost any crystal can be used in this circuit providing it is in the range 1MHz to 5MHz for a Z-80 or up to 8MHz for a Z-80A. If a crystal other than 4MHz or colour-burst is used, it will be necessary for you to carry out your own conversion for timing etc. if a real-time situation is required.

An inverter is also necessary to invert the Data Available line from the keyboard encoder to the NMI line of the Z-80 so that the NMI line goes low when data is available from the keyboard encoder. This is provided via one of the unused inverters of the 74LS04.

The oscillator circuit is a simple twin inverter using feedback resistors.

A 100pf capacitor at the front end provides guaranteed start-up and the crystal provides a capacitive feedback that is a maximum at the fundamental frequency of the crystal.

This is why the oscillator circuit operates at the frequency as specified on the crystal.

A 100n capacitor on the oscillator module reduces noise on the power rails and a 330R pull-up resistor in the clock line guarantees a full amplitude waveform for the Z-80.

To convert the TEC to crystal control, remove the 4049 and plug in the crystal oscillator board. The speed control pot will have no effect and the speed of execution of the monitor will be about double.

This will too fast for many of the games and you may have to convert back to the adjustable speed by replacing the 4049 by pressing the reset button and keeping it pressed while changing over the clocks.

## PARTS

- 1 - 330R
- 2 - 1k
  
- 1 - 100pf ceramic
- 1 - 100n monoblock
  
- 1 - 3.5795MHz crystal
  
- 1 - 74LS04 IC
  
- 1 - 7473 IC
  
- 2 - 14 pin IC sockets
- 1 - 16 pin dip header
  
- 1 CRYSTAL OSCILLATOR PC BOARD**

All future programs will have to be written especially for the new speed and this will mean delay values etc will have to be lengthened accordingly.

## ASSEMBLY

Assembly is very simple and we suggest, as always, that the two chips be fitted via IC sockets. The two 1k resistors stand upright and the 330R lays flat against the PC board. The leads of the crystal must be left long enough to allow the crystal to lay over after it has been soldered and a wire strap placed over the body to prevent it being damaged, as the leads are very thin.

The 100pf and 100n are fitted against the PC board and soldered in the positions shown. Don't get them swapped over or the oscillator won't work!

The module is connected to the TEC via a 16 pin dip header soldered under the board.

If the cermet pot on the TEC is a stand-up version, it will be necessary to include a wire-wrap socket between the dip header and the board to create additional clearance for the pot. This is not supplied in the kit as you can fold the cermet pot over slightly to allow the clock board to fit.

When you have the new board in place, the first program you can try is the Clock in issue 12, P.23. The best idea is to type

it into the non-volatile RAM at **1000** and down-load it to **0900** via a block-transfer program:

```
11 00 10
21 00 09
01 A0 00
ED B0
C7
```

To convert the program to operate with 4MHz crystal, two of the inbuilt delay values must be altered and a 'fine tune' delay added to the end of the program. This will create a clock that is accurate to within a second a day.

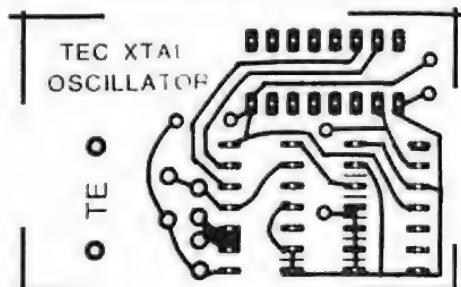
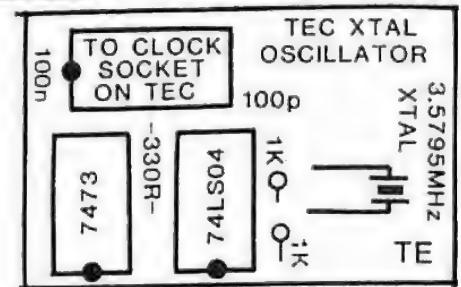
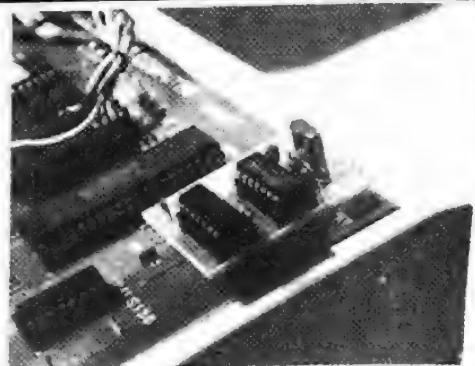
Type the complete program as per issue 12 then change the following locations and also add the extra 7 bytes:

### For a 4MHz crystal:

```
94C 06 FA
962 1E 41
970 C3 93 09
993 06 55
995 10 FE
997 C3 00 09
```

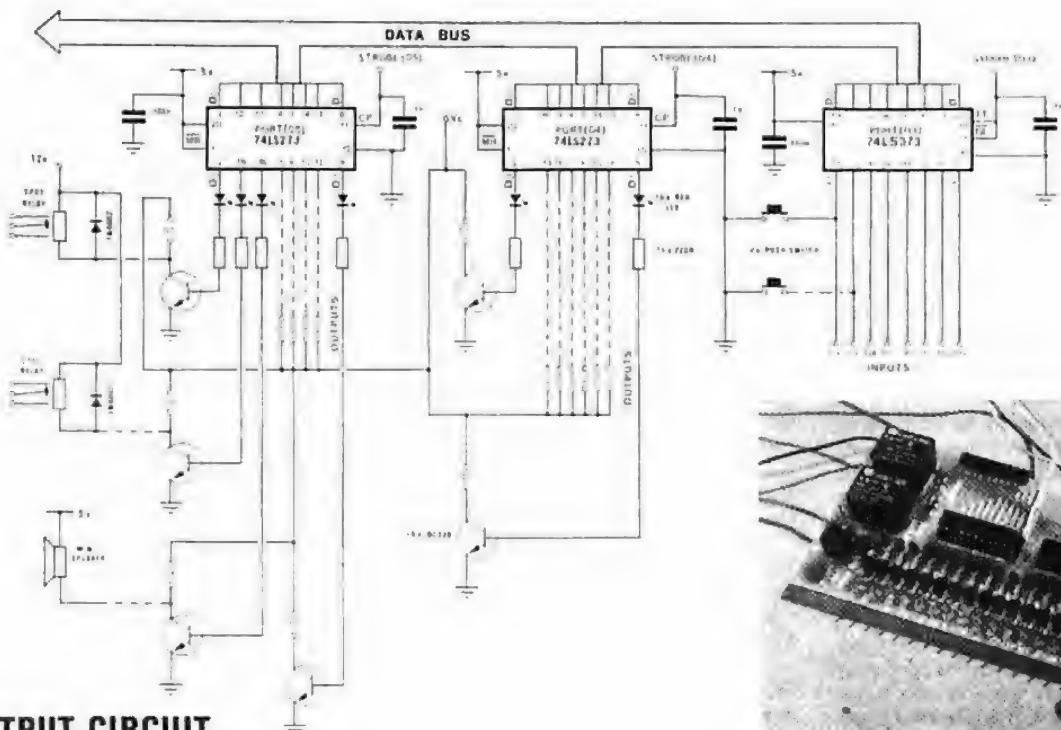
### For a 3.5795MHz crystal:

```
94C 06 FC
962 1E 39
970 C3 93 09
993 06 37
995 10 FE
997 C3 00 09
```



# INPUT/OUTPUT MODULE

Kit of parts: \$33.80  
PC Board: \$5.00  
Complete: \$38.80



## INPUT/OUTPUT CIRCUIT

This project allows the TEC to talk to the outside world and also accept information from the outside. It is the first interface we have described that brings the possibility of robotics to the TEC.

The INPUT/OUTPUT MODULE has one input port and two output ports. This means it will input 8 bits (8 lines) and output 16 bits (16 lines).

To allow the module to be functional as soon as it is constructed we have included two input switches and three output devices so that a simple program can be written and seen in operation. The output devices are two relays and a mini speaker. These will allow you to test the board and see how it operates, before adding any other devices.

We have included some test programs in the article and they will show the indicator LEDs in operation.

These LEDs indicate when a particular output is high and will be invaluable when trouble-shooting a fault in either a program or in hardware.

The 5 flying leads on the module are clearly marked and you will see the input port is controlled via strobe line 03 and output ports via strobe lines 04 and 05.

Each of the 8 input and 16 output lines is further identified by a hex value on the PC overlay and this will assist you when writing a program.

The most interesting use for the board will undoubtedly be for robotics and when designing in this field, a whole new world of mechanical and electromechanical terms will be encountered.

Before embarking on a design, it is important to have some idea of what you are going to create. It may be an arm, a wheeled vehicle or a mechanical controller such as a door opener, a lift, crane or remote controlled boat or plane.

No matter what the project, begin by collecting articles and notes describing similar or related devices and study how other designers have put things together. Combine the features you like and make sketches and diagrams of how you intend yours to look.

The most important point is not to be too ambitious on your first attempt. Aim for a simple design, using maybe a single motor and gearbox with say one or two flashing lights and a speaker.

You will have sufficient interfacing problems with these to keep your inventive skills at work for a while.

The other point to remember is to select materials that you can readily obtain and don't choose thick material as this will be very difficult to work with.

## PARTS

16 - 220R 1/4watt

3 - 1n greencap  
2 - 100n

2 - 1N 4002 diodes  
16 - 3mm red LEDs  
16 - BC 338 transistors

2 - 74LS273 IC  
1 - 74LS373 IC

3 - 20 pin IC sockets  
2 - PC mount push buttons  
1 - Mini Speaker 80R  
2 - SPDT relays

50cm tinned copper wire  
5 - PC matrix pins  
5 - Matrix connectors  
10cm - Heatshrink tubing  
15 - 20cm lengths of hook-up flex

20cm - 10 core ribbon cable  
1 - 12 key telephone pad

1 - INPUT/OUTPUT MODULE PC

3mm clear plastic sheet is the best choice as it can be cut, bent, folded and even heated into shape. It also looks appealing and being clear, you can see through it and this makes the project look more complex!

Equally suitable is PC board as it has a copper surface that can be soldered to and thus small brackets can be added for shafts etc.

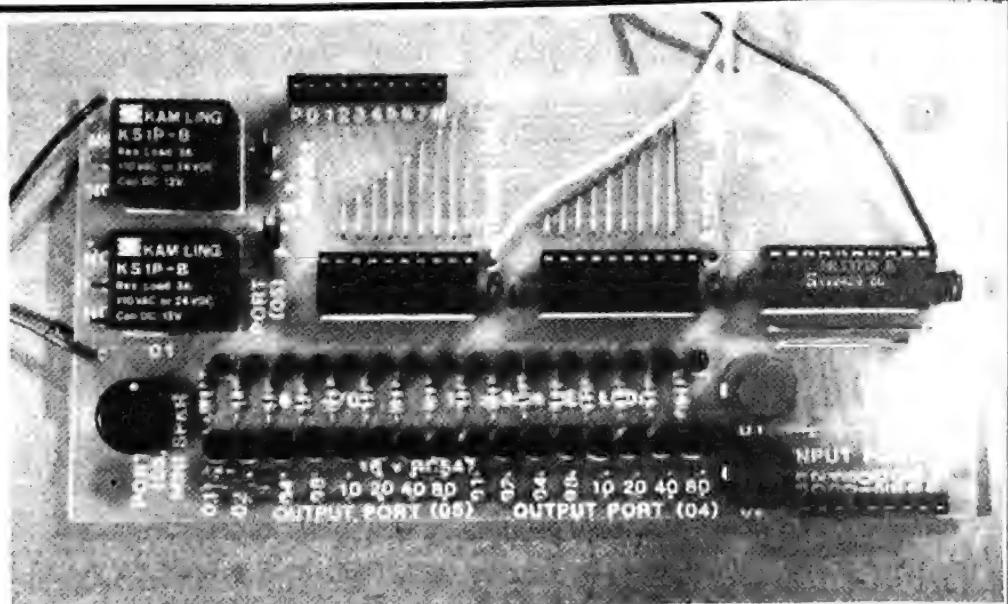
The only material I would avoid is sheet metal. Even though it has good strength, the same can be provided via plastic with the use of a few strengthening pieces, without the difficulty of cutting, folding and drilling. For tinplate to have any strength it must be reasonably thick and you will require heavy duty tools etc to shape it.

Another handy medium is wood, however this should be restricted to base panels and platforms, where a number of items need to be screwed into position. You should only use soft wood, as it will be lighter and easier to drill and screw into. Don't use nails for fixing or joining as they tend to work lose.

Lastly, don't be frightened to use parts you already have on hand, especially from the kitchen and laundry where you will find plastic bottles, lids and boxes ideally suited for turning into pulleys and wheels. Use all your imagination and initiative - you will need it as you are basically breaking new ground!

In robotics, lots of new terms need to be understood to make the project function properly. But the best way is the hard way. By trial and error. Terms like gear ratios, torque, drive speeds, strength of beams, can involve an enormous amount of mathematics. That's why it's best to look through articles and see how it has been done by others.

At the time of writing, only a very limited range of motors and gearboxes are available at the low end of the market and the best of these we found at Dick Smith Electronics.



The gearboxes are in kit form and require a small amount of assembly to fit the gears onto the shafts to produce a gearbox known as a compound gearbox.

A gearbox reduces the rotational speed of a motor and at the same time increases the torque.

Torque is the twisting or turning force of a shaft and after 3 or 4 gear reductions, a shaft will have a considerable turning force.

This will be sufficient to turn wheels or move a robot arm or lift a weight. Sometimes it is necessary to convert rotation into straight-line motion and this can be done with a rack and pinion, winch and string, crank and arm or wheel and track.

Apart from the problems you will encounter adapting the mechanics into the available space, there will be problems interfacing the motor to the electronics.

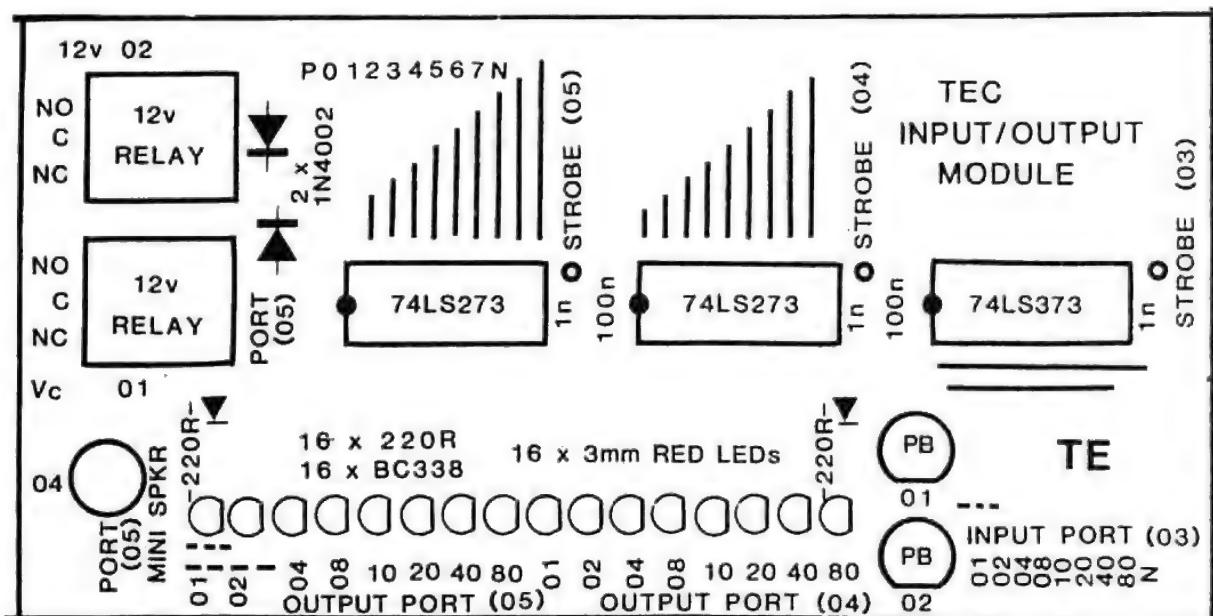
One of the major problems will be noise. Motors are inherently high noise producers and they must be kept far away from the electronics, both physically and electrically.

This may require a separate power supply so that noise and glitches from the motor do not get into the computer bus lines.

It will also be necessary to have high current available for the motor(s) as they draw a high current under load and if they stall, you must have sufficient current available to allow them to restart as soon as the load reduces.

A stalled motor can create a virtual short circuit and if connected to the computer 5v supply, the computer may drop out.

This has been avoided on the INPUT/OUTPUT MODULE by providing a separate supply line for the collectors of the output transistors and also the relays.



This will allow you to select your own supply voltage, with the necessary current capability.

When you are driving a motor, there will be three functions (or commands) needed. These are: ON/OFF (one command) FORWARD and REVERSE.

To achieve this, a number of lines (bits) will be required from the output port. Depending on the circuit used to drive the motor, either 2 or 3 bits will be required.

If you require the motor to operate in the forward direction as well as reverse, it will be necessary to use a relay. For a simple ON/OFF and FORWARD direction, a transistor can be used and only one bit (1 line) will be required. You can also get speed control from this line by including it in the program.

Basically speed control consists of outputting a high for a short duration and a low for a long duration and repeating the sequence about 100 times per second. To increase the speed, the duration of the high is increased and the low decreased. The only feature that remains constant is the repetition rate. It is essential to keep the pulses above 100Hz so that the motor rotates smoothly.

## ASSEMBLY

By now you will be familiar with our assembly technique. Neatness is the overall aim. No matter how you build, the final result must be as neat as possible. This means the jumper links must be straight and sitting firm against the board, the LEDs must be close to the board and likewise the transistors, resistors and diodes. I thought it would be unnecessary to mention these points but we are still getting projects for repair in which the parts are mounted high above the board, the jumper links are twisted and kinked and the soldering is rough.

On the topic of soldering. It is important to use enough solder to cover the land and the hole. Again, we are seeing the smallest amount of solder on some joints, just enough to tack the lead to the land!

This is a very dangerous situation as you can create a problem that will be very difficult to locate. Sometimes the holes in the PC board cut through the track and the circuit relies on the solder to bridge the gap.

If you don't solder all around the lead, the copper track may contain a gap and obviously the project will fail to operate. Inspect the board before starting and check your workmanship after construction and you should have no problems in this area.

Begin assembly with the jumpers. Make sure they are straight and touching the board.

Next fit the resistors, followed by the LEDs, transistors and two spike-

suppressing diodes. The overlay shows how these components are placed.

The 5 spike-suppressing capacitors are next and must be fitted close to the board. The IC's are mounted in sockets and the dot on the overlay indicates pin 1. You will find one end of the IC socket has a 'cut-away' portion to match with pin 1.

Fit the relays, mini speaker and switches. Then inspect the board to make sure all leads have been soldered properly.

After adding all the parts to the board, the 5 jumper lines are added and a female matrix connector soldered to each lead. These are covered with heatshrink to prevent shorting between leads when connecting to the TEC board.

## MATRIX PINS

You will notice the module in the photographs has a set of matrix pins on the output ports and also the relays. These pins are not included in the kit however you can buy some and fit them as shown in the photo if you wish.

The 5 pins included in the kit are for adding to the TEC PC board to take the 5 flying leads from the input/output board.

Paul has included a 9 pin input plug and a 10 pin plug for connecting to the TEC. These are not included in the kit but can be easily made from 18 pin and 20 pin IC sockets. They are small and delicate but will last a number of insertions and removals.

## TESTING

The first program in the list is the test program. It has a short routine to flash the output LEDs so that every second LED is lit and then the others are flashed. The program repeats this a number of times then changes to detect an input from the input port. The result is indicated on the corresponding output LED.

If this sequence is not observed, the program should be double-checked. Make sure it contains the correct commands. Then check the flying leads. They must be connected to the correct outputs on the decoder chip. Refer to the line diagram for the position of each lead.

## TEST PROGRAM

<b>LD B,10</b>	<b>0900</b>	<b>06 10</b>
<b>LD A,AA</b>	<b>0902</b>	<b>3E AA</b>
<b>OUT (04),A</b>	<b>0904</b>	<b>D3 04</b>
<b>OUT (05),A</b>	<b>0906</b>	<b>D3 05</b>
<b>CALL DELAY</b>	<b>0908</b>	<b>CD 50 09</b>
<b>LD A,55</b>	<b>090B</b>	<b>3E 55</b>
<b>OUT (04),A</b>	<b>090D</b>	<b>D3 04</b>
<b>OUT (05),A</b>	<b>090F</b>	<b>D3 05</b>
<b>CALL DELAY</b>	<b>0911</b>	<b>CD 50 09</b>
<b>DJNZ</b>	<b>0914</b>	<b>10 EC</b>
<b>LD A,00</b>	<b>0916</b>	<b>3E 00</b>
<b>OUT (04),A</b>	<b>0918</b>	<b>D3 04</b>
<b>OUT (05),A</b>	<b>091A</b>	<b>D3 05</b>
<b>IN A,(03)</b>	<b>091C</b>	<b>DB 03</b>
<b>CPL</b>	<b>091E</b>	<b>2F</b>
<b>OUT (04),A</b>	<b>091F</b>	<b>D3 04</b>
<b>JR</b>	<b>0921</b>	<b>18 F9</b>

<b>LD DE,0000</b>	<b>0950</b>	<b>11 00 00</b>
<b>DEC DE</b>	<b>0953</b>	<b>1B</b>
<b>LD A,D</b>	<b>0954</b>	<b>7A</b>
<b>OR E</b>	<b>0955</b>	<b>B3</b>
<b>JRNZ</b>	<b>0956</b>	<b>20 FB</b>
<b>RET</b>	<b>0958</b>	<b>C9</b>

The second program is a 12-note organ using a soft-touch key pad for the input and the mini speaker on the IN/OUT module as the output.

The idea of an organ may have limited possibilities in itself, but the knowledge of how to produce a tone will be very beneficial.

In robotics, for instance, a mouse can be equipped with a speaker to produce a tone when it touches an obstacle etc. The note sounds for as long as the robot touches the object.

The importance of the program is to show how a tone is produced and how the pitch can be altered by adjusting the delay value.

Follow through the program and see how this is done:

## ORGAN PROGRAM

<b>XOR A</b>	<b>0900</b>	<b>AF</b>
<b>OUT (01),A</b>	<b>0901</b>	<b>D3 01</b>
<b>OUT (02),A</b>	<b>0903</b>	<b>D3 02</b>
<b>OUT (04),A</b>	<b>0905</b>	<b>D3 04</b>
<b>OUT (05),A</b>	<b>0907</b>	<b>D3 05</b>
<b>LD HL,09FF</b>	<b>0909</b>	<b>21 FF 09</b>
<b>IN A,(03)</b>	<b>090C</b>	<b>DB 03</b>
<b>CP FF</b>	<b>090E</b>	<b>FE FF</b>
<b>JR Z,090C</b>	<b>0910</b>	<b>28 FA</b>
<b>LD BC,03FF</b>	<b>0912</b>	<b>01 FF 03</b>
<b>DEC BC</b>	<b>0915</b>	<b>0B</b>
<b>LD A,B</b>	<b>0916</b>	<b>78</b>
<b>OR C</b>	<b>0917</b>	<b>B1</b>
<b>JR NZ,0915</b>	<b>0918</b>	<b>20 FB</b>
<b>IN A,(03)</b>	<b>091A</b>	<b>DB 03</b>
<b>INC HL</b>	<b>091C</b>	<b>23</b>
<b>INC HL</b>	<b>091D</b>	<b>23</b>
<b>CP (HL)</b>	<b>091E</b>	<b>BE</b>
<b>JR NZ,091C</b>	<b>091F</b>	<b>20 FB</b>
<b>INC HL</b>	<b>0921</b>	<b>23</b>
<b>LD B,(HL)</b>	<b>0922</b>	<b>46</b>
<b>DJNZ 0923</b>	<b>0923</b>	<b>10 FE</b>
<b>LD A,04</b>	<b>0925</b>	<b>3E 04</b>
<b>OUT (05),A</b>	<b>0927</b>	<b>D3 05</b>
<b>LD B,(HL)</b>	<b>0929</b>	<b>46</b>
<b>DJNZ 092A</b>	<b>092A</b>	<b>10 FE</b>
<b>XOR A</b>	<b>092C</b>	<b>AF</b>
<b>OUT (05),A</b>	<b>092D</b>	<b>D3 05</b>
<b>IN A,(03)</b>	<b>092F</b>	<b>DB 03</b>
<b>CP FF</b>	<b>0931</b>	<b>FE FF</b>
<b>JR NZ,0922</b>	<b>0933</b>	<b>20 ED</b>
<b>JR 0909</b>	<b>0935</b>	<b>18 D2</b>

at 0A00:		
00	64	3C
FA	BD	CF
84	5C	34
DE	F3	AF
7C	54	2C
BE	D7	FF
74	4C	
F9	B7	
6C	44	
DD	EB	

## KEY PAD CONTROLS OUTPUT LINES

The third program controls the 16 output lines via a 12-key phone pad.

To turn on one of the left-hand outputs (port 05), press the asterisk key then a number button from 1-8. The right-hand port (port 04), is accessed by pressing the 'hatch' key then a number from 1-8.

When a second number key is pressed, the corresponding output-line changes state. Thus a high output will go low and vice versa. To access the other latch, one of the control keys (asterisk or hatch) must be pressed.

The program is fully described beside each instruction and this will assist you to design your own programs.

An important point to remember is DEBOUNCE. The soft-touch keys require a time to settle down before a value can be read. This means a short delay must be included in the program (see address 0913 and 0914).

The reason is the contacts in the pad are made from a carbon compound and they create a considerable amount of bounce when a key is pressed.

Since the computer is a high-speed piece of equipment, it will pick up an incorrect value if the three contacts in the switch are not closed when it is being read.

To overcome this a short delay is introduced between the time when a key is pressed and when it is read.

The program can be modified to suit your own requirements. For example: a random output can be turned ON, or more than one output can be turned ON at the same time. A delay could be introduced to turn OFF and output after a set period of time or you could create a visual effect on a set of LEDs.

It's up to you. Study the program and try making some modifications.

For a very simple test program, try this:

**3E FF  
D3 04  
C7**

Eight LEDs will illuminate to show the program and board is working.

*Wiring diagram showing the connection of the phone pad to the input/output module, and the module to the DIP header plug. Note: line '80' is not used when connecting the phone pad.*

*Photo, left: Motor and gearbox with two 100/16v electrolytics placed back-to-back to create a non-polar capacitor to reduce spikes from the motor. (i.e. the positive lead of each electro connects to a motor lead and the join of the negative leads is left floating).*

*Photo, right: The key pad connected to the input/output module via ribbon cable and to the TEC via hook-up flex.*

<b>XOR A</b>	<b>0900</b>	<b>AF</b>
<b>LD B,0B</b>	<b>0901</b>	<b>06 0B</b>
<b>LD C,04</b>	<b>0903</b>	<b>0E 04</b>
<b>LD (BC),A</b>	<b>0905</b>	<b>02</b>
<b>INC C</b>	<b>0906</b>	<b>0C</b>
<b>LD (BC),A</b>	<b>0907</b>	<b>02</b>
<b>LD HL,09FF</b>	<b>0908</b>	<b>21 00 0A</b>
<b>LD D,00</b>	<b>090B</b>	<b>16 00</b>
<b>IN A,(03)</b>	<b>090D</b>	<b>DB 03</b>
<b>CP FF</b>	<b>090F</b>	<b>FE FF</b>
<b>JR Z,090D</b>	<b>0911</b>	<b>28 FA</b>
<b>DEC D</b>	<b>0913</b>	<b>15</b>
<b>JR NZ,0913</b>	<b>0914</b>	<b>20 FD</b>
<b>IN A,(03)</b>	<b>0916</b>	<b>DB 03</b>
<b>INC D</b>	<b>0918</b>	<b>14</b>
<b>INC HL</b>	<b>0919</b>	<b>23</b>
<b>CP (HL)</b>	<b>091A</b>	<b>BE</b>
<b>JR NZ,0918</b>	<b>091B</b>	<b>20 FB</b>
<b>CP EB</b>	<b>091D</b>	<b>FE EB</b>
<b>JR NZ,0925</b>	<b>091F</b>	<b>20 04</b>
<b>LD C,05</b>	<b>0921</b>	<b>0E 05</b>
<b>JR 0945</b>	<b>0923</b>	<b>18 20</b>
<b>CP AF</b>	<b>0925</b>	<b>FE AF</b>
<b>JR NZ,092D</b>	<b>0927</b>	<b>20 04</b>
<b>LD C,04</b>	<b>0929</b>	<b>0E 04</b>
<b>JR 0945</b>	<b>092B</b>	<b>18 18</b>
<b>LD A,(BC)</b>	<b>092D</b>	<b>0A</b>
<b>LD E,D</b>	<b>092E</b>	<b>5A</b>
<b>RRCA</b>	<b>092F</b>	<b>0F</b>
<b>DEC D</b>	<b>0930</b>	<b>15</b>
<b>JR NZ,092F</b>	<b>0931</b>	<b>20 FC</b>
<b>BIT 7,A</b>	<b>0933</b>	<b>CB 7F</b>
<b>JR Z,093B</b>	<b>0935</b>	<b>28 04</b>
<b>RES 7,A</b>	<b>0937</b>	<b>CB BF</b>
<b>JR 093D</b>	<b>0939</b>	<b>18 02</b>
<b>SET 7,A</b>	<b>093B</b>	<b>CB FF</b>
<b>LD D,E</b>	<b>093D</b>	<b>53</b>
<b>RLCA</b>	<b>093E</b>	<b>07</b>
<b>DEC D</b>	<b>093F</b>	<b>15</b>
<b>JR NZ,093E</b>	<b>0940</b>	<b>20 FC</b>
<b>LD (BC),A</b>	<b>0942</b>	<b>02</b>
<b>OUT (C),A</b>	<b>0943</b>	<b>ED 79</b>
<b>IN A,(03)</b>	<b>0945</b>	<b>DB 03</b>
<b>CP FF</b>	<b>0947</b>	<b>FE FF</b>
<b>JR NZ,0945</b>	<b>0949</b>	<b>20 FA</b>
<b>JP 0908</b>	<b>094B</b>	<b>C3 08 09</b>

Data for port 05 is stored at 0A05 and 0A04 for port 04. These two locations are initially cleared in the first 6 lines of the program. Later, you will see why we have chosen registers B and C for this operation.

HL is the pointer for the byte table.

D is the count register for the key.

The program inputs via port 03, looking for a key press. Any value other than FF will exit from the loop. A short delay is created via the D register to give the pressure sensitive keypad switches a short period of time to settle to a value that can be read correctly. Input this key value via port 03 to the accumulator. The next 4 lines generate a value for D that will be the same as the key. This is done via a loop and incrementing D until the key value compares with the byte in the table will make D equal the key value. The next 8 lines look for the STAR key or HATCH key and if either is pressed, C is loaded with either 05 or 04. This will allow the program to output to the correct port via the instruction OUT (C),A Also locations 0A05 and 0A04 use the C register for storage. In this way the C register serves a dual role and some of the powerful instructions such as OUT (C),A can be employed.

Load A with the byte at location 0A05 or 0A04. Store the key value for later use.

The next 3 lines rotate the accumulator so that the wanted bit is rotated to the end of the register and thus only one TEST will be required.

Look at the highest bit and jump if it is zero. Otherwise execute next instruction.

At this line the bit will be '1' and thus the program resets it to '0' and a jump is performed.

The highest bit is SET via this instruction.

Load D with the key value in readiness for rotating the accumulator back to its previous position. RLCA is a single byte instruction that rotates the accum and sets the carry flag. The bits don't enter the CARRY.

Store the resulting byte in memory.

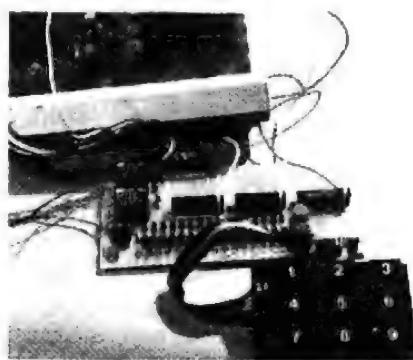
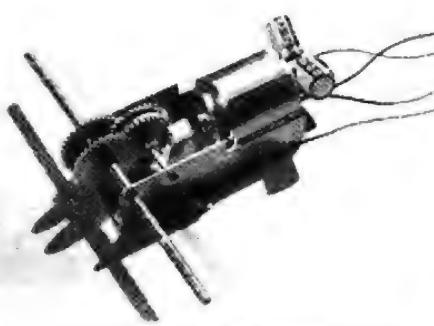
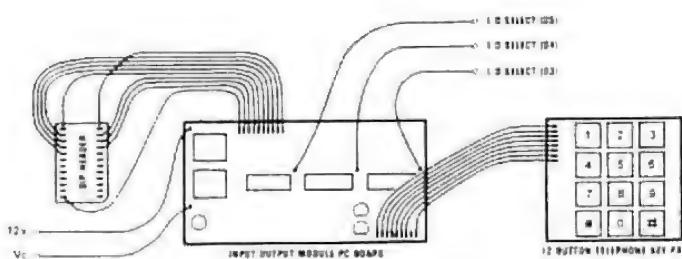
Output the byte to either port 05 or 04.

Look at the input port and loop the next 3 instructions until the key has been released. This is a debounce routine, essential to produce a clean key action.

Jump to the start of the main part of the program.

### At 0A00:

**FA**  
**DE**  
**BE**  
**F9**  
**DD**  
**BD**  
**F3**  
**D7**  
**B7**  
**CF**  
**EB**  
**AF**

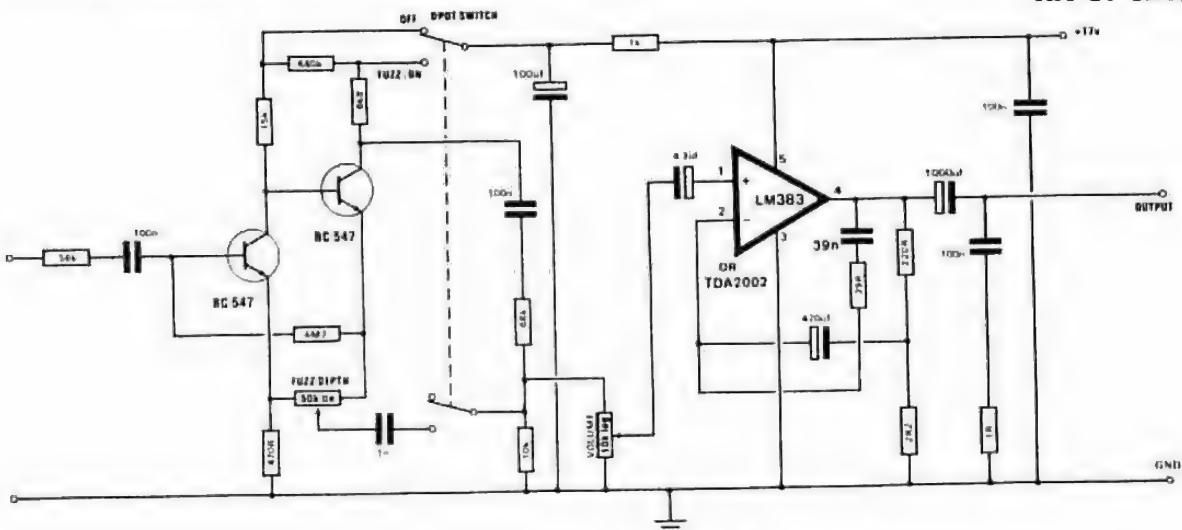


# GUITAR PRACTICE AMPLIFIER

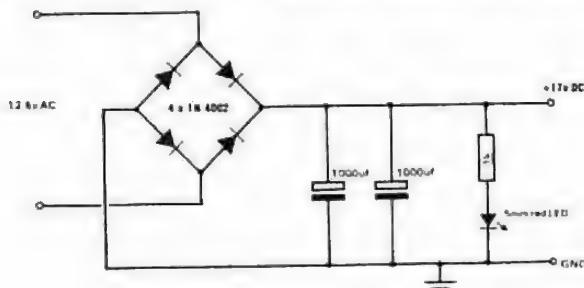
AN 8-WATT AMPLIFIER WITH PRE-AMP AND FUZZ



Kit of parts: \$12.30  
PC Board: \$3.40  
Complete: \$15.70  
Kit of extras: \$26.40



GUITAR PRACTICE AMPLIFIER CIRCUIT



POWER SUPPLY (INBUILT)

Following the success of the 8-watt amplifier in issue 9, Paul has designed a project around the 8-watt chip and the result will have an even wider appeal.

It's an amplifier with a built-in pre-amp section, a fuzz section and a power supply which makes the unit completely self-contained.

As an amplifier it can be used as a mini amp for halls or outdoor events while the fuzz effect makes it suitable for guitar practice etc.

The circuit is quite simple as the use of a single chip eliminates the need for the usual array of components. It also makes the project extremely reliable as most of the work associated with biasing and matching of output devices has already been done.

It just takes a few external components to get the chip operating and a few more to create the pre-amplifier/fuzz section. The power supply is merely a set of diodes and a filter electrolytic, this being found adequate to eliminate any hum.

## PARTS LIST

1 - 1R 1/4watt	1 - 10k
1 - 2R2	1 - 15k
1 - 39R	1 - 56k
1 - 220R	1 - 68k
1 - 470R	1 - 680k
2 - 1k	1 - 4M7
1 - 6k8	

1 - 10k mini trim pot  
1 - 50k mini trim pot

1 - 1n greencap  
1 - 39n  
4 - 100n

1 - 4u7 25v PC mount electro  
1 - 100uF 25v PC mount  
1 - 470uF 25v PC mount  
3 - 1000uF 25v PC mount

2 - BC 547 transistors  
4 - 1N 4002 diodes  
1 - 5mm red LED  
1 - LM 383 (TDA 2002) IC

1 - DPDT slide switch  
1 - Mini U heatsink  
1 - 6BA nut and bolt

1 - GUITAR AMP PC BOARD

In the past, we have been hesitant to include a transformer in any of the projects as it requires working on components that will carry the 240v supply.

We have now overcome much of the previous apprehension by laying out the wiring in such a way that the live terminations can be completely covered with heatshrink, thus totally eliminating possible contact with the mains voltage.

**This means the assembly must be carried out strictly according to instructions and the wiring checked by an authorised supervisor before connecting the project to the mains.**

Even though the mains section involves only about 4 or 5 connections, the possibility of a faulty or misplaced lead is always there, and thus someone else must check your work before plugging it into the outlet.

Once again, the LM 383 amplifier chip has been used as it is virtually impossible to damage with overload.

In our circuit, we are supplying a safe operating voltage and include an electrolytic in the output, thus offering no cause for complaint. The chip is designed to deliver its full output wattage into 1.6 ohms and even if the output leads are shorted together, the internal temperature limiting circuit will prevent the chip from getting too hot.

The advantage of delivering into a low impedance such as this means the amplifier can be connected to up to five 8ohm speakers in parallel and each speaker will be supplied with about 2 watts.

It works like this: If you connect one 8ohm speaker to the output, the wattage from the chip will be about 2 to 3 watts. If another 8ohm speaker is added to the output, the power delivered by the chip will be about 5 watts. This is 2.5 watts per speaker.

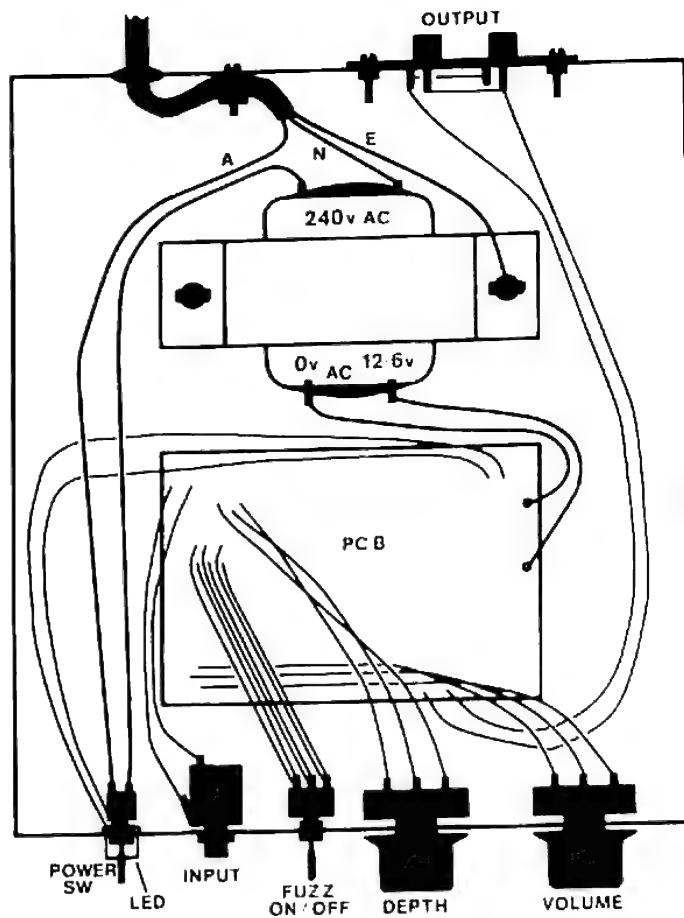
When 3 speakers are connected, the output power rises to 6 watts so that when 4 speakers are connected the power becomes about 8 watts. The data on the chip indicates the output power is about 10 watts when the load is 1.6 ohms but these figures are absolute maximum and would only occur on peak signals.

The main point to realise is the fact that the power delivered to each speaker does not alter appreciably as the number of speakers is increased.

This is handy if you wish to use the amplifier in a hall, or large room, where you may need full power.

The terms: POWER, MUSIC POWER, DECIBELS, and RMS OUTPUT are all very difficult to grasp and far too much discussion has been centred around trying to explain what they mean.

**We are not intending to make an amplifier  
that will damage your eardrums or fill a**



concert hall and so the loudness of the amplifier is of no real concern.

The reason why all these terms are hard to grasp is because the energy required to increase the loudness of a sound is not linear but a logarithmic scale and as such we can make the amazing comment that to double the loudness from the speakers would require an amplifier of about 50 watts. See how irrelevant figures are!

The only way to determine the suitability of an amplifier is to build it and use it.

**Providing you don't expect too much from 8 watts, you will find this project to be adequate for all types of situations.**

In fact we think it is loud enough to call it a Guitar Practice Amplifier. And you can

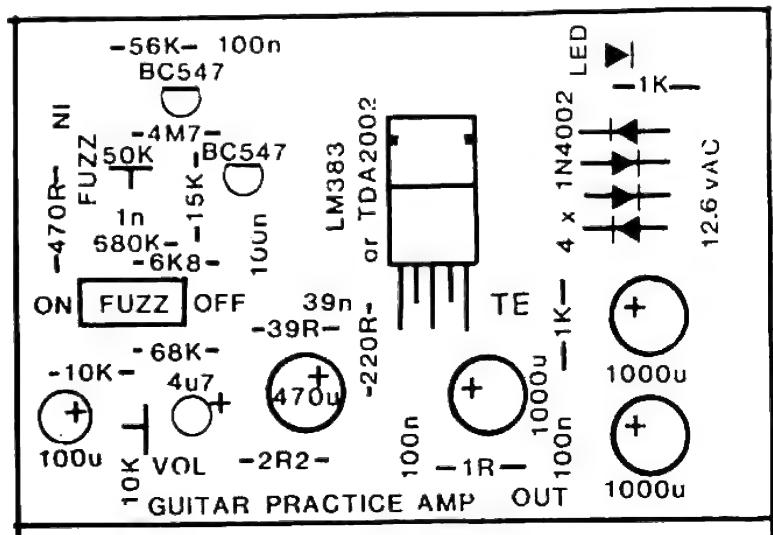
be sure neighbours from two or three doors down will hear you practicing.

Most of the effectiveness of an amplifier is in the speakers and there is one enormous misunderstanding concerning them.

Most people think large speakers require more power to drive them and as such you must use speakers capable of handling say 2 watts. for this project. But this is not so.

The wattage rating on a speaker refers to its maximum power handling capability, and you could quite comfortably use four 15 watt speakers for this project.

The reason why large speakers are to be preferred in any amplifier system is due to the large amount of cone area they offer.



As the cone of the speaker moves in and out, it shifts an equally large amount of air. It is this air which forms the sound waves that are picked up by the ear.

Obviously there are certain limits to this analogy but large speakers will certainly produce more room-filling sound than small ones.

To this extent it is not a bad choice to use a speaker capable of handling 15 watts, for a 2-watt amplifier.

## HOW THE CIRCUIT WORKS

This project is based on a single amplifier chip LM 383 and as the schematic diagram shows, it can be thought of as an amplifier block with an inverting and a non-inverting input.

Provided the circuit board is correctly designed, the chip is highly reliable and produces a very clean output when supplied by smoothed DC in the range 12v to 18v. (Note: the SGS type MUST NOT be supplied with more than 18v as it has automatic switch-off at 18v!!).

A portion of the signal is taken from the output and fed into the inverting input to provide negative feedback. This reduces the output power slightly but more important it reduces the distortion.

Although we may want a considerable amount of distortion when in the fuzz mode, we require the amplifier section to be relatively distortion free so that it can be used as a PA amplifier etc.

The pre-amplifier/fuzz section is a clever design. It consists of two transistors and by using a switch, the bias on the two can be altered so that they change from amplifying mode to distortion mode.

This distortion mode is called fuzz and as they try to amplify, the high value of collector resistor causes the supply voltage to fall and thus the signal becomes distorted.

In addition, an AC feedback path is created via the 100n, 68k, 10k, 1n and 50k pot and this further upsets the DC bias so that the characteristic fuzz can be adjusted in depth.

When the fuzz switch is turned off, the first transistor provides a small amount of amplification to increase the input waveform about 2 times.

The power supply is a simple rectified and smoothed supply, suitable for the LM 383 chip, with an indicator LED on the supply line to show when the unit is on.

## CONSTRUCTION

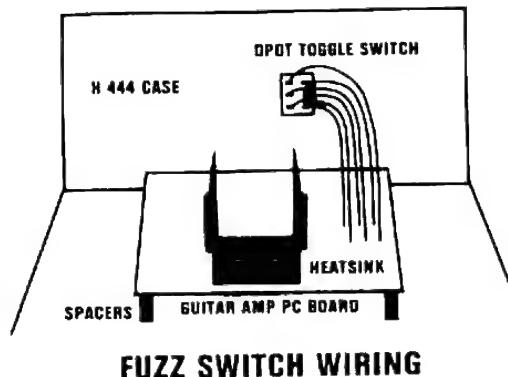
It is essential that this project be built on a PC board as the characteristics of the LM 383 are such that it requires a heavy earth plane to be present.

Without a tight earth plane and the hum reducing kink in the PC track, there is a tendency for the amplifier to generate its own background hum.

Only after designing 3 different PC layouts did we reduce the background hum to near zero. That's why we suggest construction on our PC board pattern.

This still allows you to make your own board from the artwork on the back page, but don't forget, our boards come with an overlay and once you have worked on boards with an overlay, you will never go back to a plain board again.

All the parts fit on the board and the controls are attached via plated leads. The twisting or plating of the leads serves to keep them neat and reduce interference between various parts of the circuit.



Only the input lead needs to be screened to reduce hum pick-up and providing the others are not too long or placed near the power transformer, no induced hum can be detected.

The parts list at the beginning of the article includes all those items required for the PC board. The 'extra' parts list below will complete the project as shown in the photos.

Start by assembling the components on the PC board. Solder the resistors in place first and then the 4 power diodes. The diodes are placed alternately one way then the other with the bar or line on the overlay representing the band on the end of the diode.

## GUITAR AMP EXTRAS

**Kit: \$26.40**

- 1 - 10k lin pot
- 1 - 50k lin pot
- 2 - knobs to suit
- 1 - 6.4mm mono socket
- 1 - 2way RCA socket
- 1 - SPDT toggle switch
- 1 - DPDT toggle switch
- 10cm heatshrink tubing 2.6mm diam
- 20 lengths of hook-up wire 15cm long
- 2 lengths of heavy duty hook-up wire
- 20cm shielded microphone cable
- 1 - 2155 transformer
- 1 - mains cord and plug
- 1 - H 444 case
- 1 - rubber grommet
- 2 - 4BA nuts and bolts
- 3 - 6BA nuts and bolts
- 4 - 1/8" whiteworth nuts & 25mm bolts
- 4 - 9mm spacers
- 1 - earth tag
- 1 - cable clamp

The 1 ohm and 2.2 ohm resistors will be new to many readers and they can be identified as follows: 1R =brown, black, gold, gold. 2R2 = red, red, gold, gold.

Next mount the amplifier chip and fit it onto the mini U heatsink with a 6BA nut and bolt. Push the 5 leads through the holes in the board and screw it into position. Make sure the leads are slightly bent as the heat from the chip will gradually expand and contract the leads and we do not want them to push on the solder lands. Bend the leads slightly and solder them in place.

Next fit the greencaps, making sure each one is identified correctly and solder them in place.

Finally the electrolytics are added to the board, making sure the negative lead as identified on the body of the electro goes down the negative hole. You will notice the positive is identified on the board and make sure this doesn't cause confusion.

This completes the PC assembly and is normally where we finish a project. But this one requires a number of external controls and so we have made an 'extras' kit containing the pots, switches, transformer, case, plugs and sockets so that you can complete the project.

The first thing to do is mount the controls on the front panel in the same relative places as in the photograph.

The switches are mounted using two nuts one on the front and one on the back of the panel, so that the switch does not protrude too far.

The same applies to the pots so that the knobs fit nearly flush with the panel. Use the line diagram on the previous page to assist you with wiring between the controls and the PC board. Each of the connecting wires should be about 15cm long to allow the board to be turned over for soldering. If the connecting wires are too short, you will experience great difficulty in repairing the board, should a fault occur.

Plat the three wires from each pot to keep them together and use different colours for each line so that they can be easily recognised at the other end.

When all the leads have been added, fit the board to the base of the case with 4 long bolts and use spacers to keep the board above the base.

Mount the transformer so that it is near the back of the case to prevent hum pick-up and use the Ov and 12.6v tags for the project.

The output sockets are a pair of RCA sockets and are mounted on the rear of the case with 2 6BA nuts and bolts. The idea of this is to allow two 8 ohm speakers to be connected to the amplifier and up to four 8 ohm speakers can be connected to realize the full 8 watts output.

The last item to add is the power lead. Use a grommet in the rear of the case and also fit a cable clamp inside to prevent the cord twisting around inside the case and straining on the lugs of the transformer.

Take the active lead directly to the switch on the front of the case and another lead from the switch to the AC input on the transformer.

The neutral lead is taken directly to the other AC tag on the transformer and the earth lead is connected to one of the legs of the transformer to make contact with the case.

It is wise to use heatshrink tubing over each of the mains voltage connections to prevent accidental touching of an exposed joint.

Check over the completed project and make sure it looks like our version. When you are satisfied all has been done, it's ready for testing.

## TESTING

Plug an electric guitar or microphone into the input socket and connect speakers to the output.

Switch the unit on and try the amplifier with the fuzz section off. You should hear a clean response, even with the volume control turned fully up. The background hum and noise should be barely audible when an input jack is inserted and will drop considerably when removed.

Switch on the fuzz and adjust the depth control. You will be most impressed with the effect. It's now up to you to put it to good use.

## FAULT FINDING

If the unit fails to operate, turn it off immediately and remove the PC board from the mounting screws. Check to see that no short-circuits exist and that all components are placed around the correct way. Also check the underside of the board for solder bridges or connections that may have been missed.

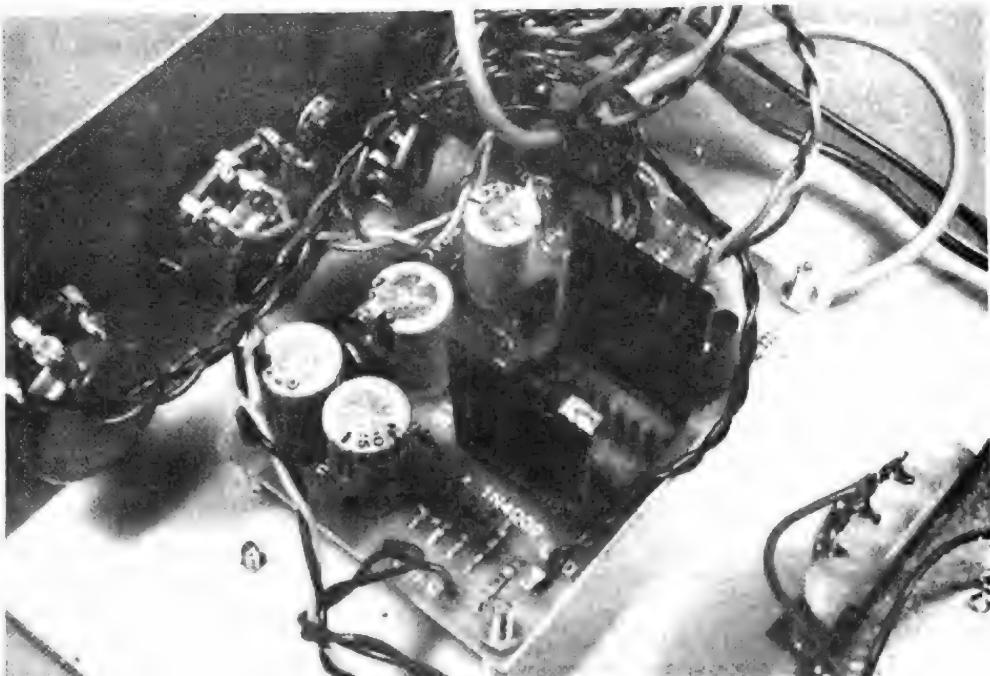
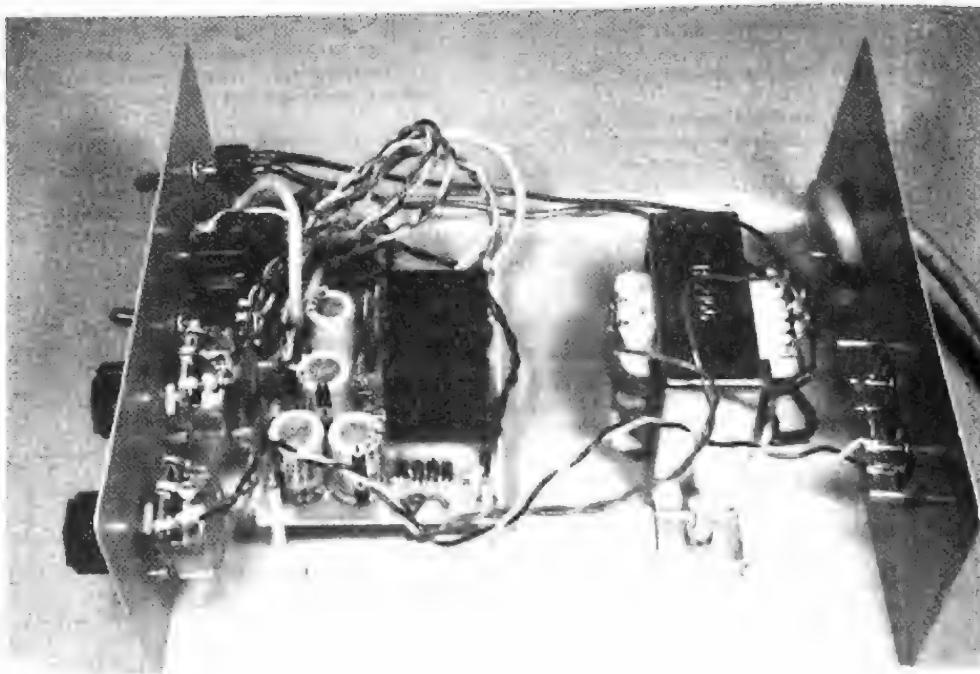
There is very little chance of a fault developing in the electronics of this project as the amplifier chip is fully protected against overload.

The most likely place to look is on the fuzz switch and input socket. If you are not sure how to wire these, use a multimeter set to low ohms and trace through the circuit before soldering.

The only other cause of a short circuit will be due to fine strands from one piece of hook-up wire touching another.

I hope you don't encounter any problems with the project and have the same success as we did.

It's a handy amplifier for those who want to practice without disturbing the rest of the household and can be used for amplifying other devices such as speech chips for the TEC computer!!



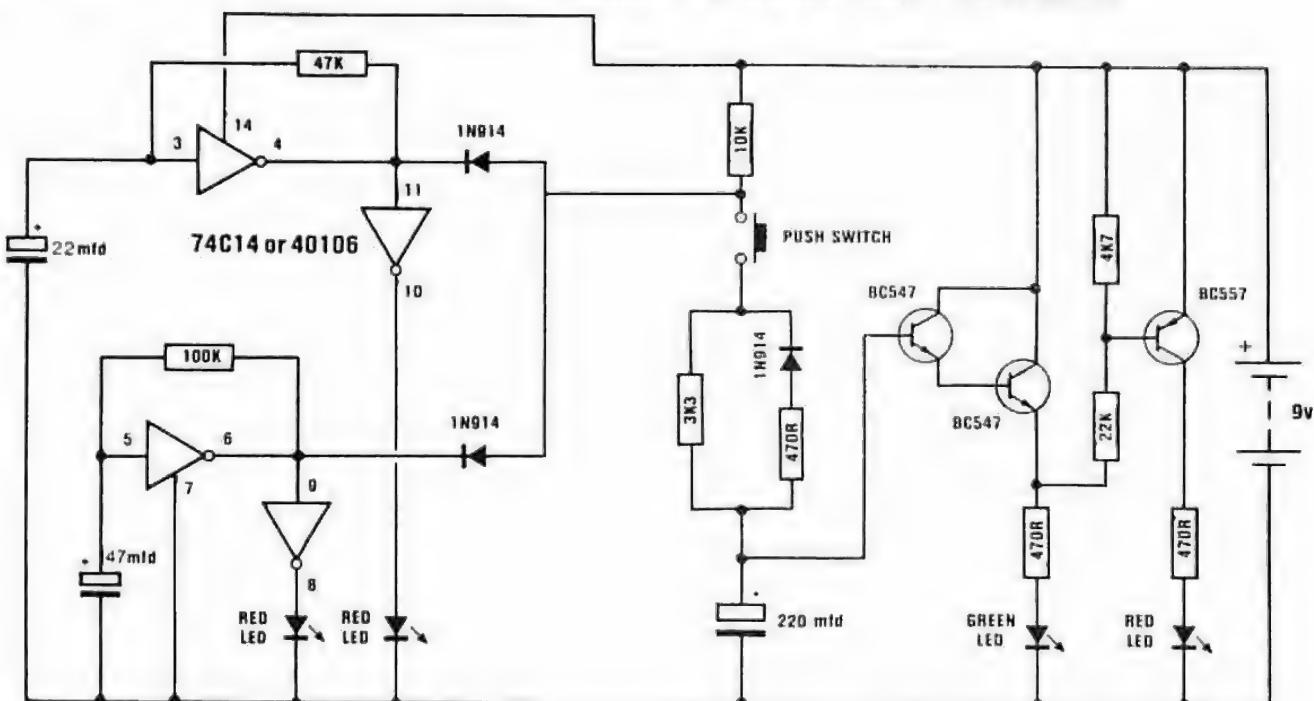
The two photos above show the wiring of the PC board to the controls, transformer and output plugs. Use these in conjunction with the layout diagram on P. 28 and also the fuzz switch diagram on P. 29 to produce a neat layout. Plat the leads to keep them together and choose multi coloured wires to make wiring easier.

The completed Guitar Practice Amplifier.



# CO-ORDINATOR

A GAME OF SKILL AND PATIENCE



CO-ORDINATOR CIRCUIT

Co-ordinator is a game of skill. It tests your reaction time and patience.

Patience because a certain condition appears only every few seconds and it corresponds to both indicator LEDs being OFF.

When the two LEDs are off, you must press the button and this supplies a little energy to a reservoir electrolytic. The voltage on this electro is detected by a high impedance amplifier and the result is shown on a "LED-pair". As the voltage rises, one of the LEDs in this pair gradually dims and its brightness is transferred to a LED of opposite colour.

This process is very gradual and may take up to 20 or 30 pushes. But if your timing is out, all the achievement of these presses will be lost to the discharge circuit.

The time when it is safe to press and NOT press, is very abrupt and you have to be very careful not to extend into the "forbidden" zone.

The circuit consists of four sections or 'building blocks' and by describing each of these fully, we cover the complete circuit.

The first building block is the low-frequency oscillator, of which there are two. Each oscillator operates independently and its rate of flash is indicated on a LED. The LED is buffered by an inverter for one very important reason.

The voltage across a LED will not rise above about 1.7v (for a red LED) and if it were connected directly to the output of the oscillator, it would stop it from operating. This is because the output must rise to more than 66% of the rail voltage so that the input can detect a HIGH and change state, due to the function of the feedback resistor. The operation of this type of circuit has been covered in ELECTRONICS Stage-1, pages 77 and 78.

The next block is the GATE, made up of two signal diodes and 10k resistor. This forms an AND gate and operates as follows: The circuit requires a HIGH on the end of the 10k resistor to charge the reservoir electrolytic and this is available ONLY when the cathode end of both diodes is HIGH.

This condition corresponds to both LEDs being OFF and thus the circuit is designed around the OFF state.

When the output of both oscillators is HIGH, the charging path for the electrolytic is via the 10k and 3k3 resistors and during the short period of time when this occurs, the button should be pressed. When either oscillator goes LOW, it brings the discharge path into operation.

The discharge path is made up of a 470R resistor and signal diode. This path has a much lower impedance than the charge path (the 3k3 resistor) and thus most of the good work done during the charging will be removed very quickly by one false move.

During charging, the diode (in series with the 470R) forms a 'blocking' effect and does not play any part in the charging.



Colin playing with the Co-Ordinator. It's more difficult than you think to get the green LED to turn on fully.

The value of the timing components is not very critical and you will see one set is about half the value of the other. This gives a flash rate of about 4:1 and means the two output LEDs are both OFF for a very small fraction of the time.

Next we come to the high impedance 'detector' circuit. It is actually an emitter follower arrangement, designed to turn ON one of the indicator LEDs.



# SHOP TALK

No matter how long it takes to get an issue out, you can't say it's not worth waiting for. We have been waiting nearly 8 months for this issue. Let's hope the next is quicker.

As we get a little more streamlined and better organised, we have come to the decision that we can bring out a publication every three months.

At least that's the intention. A quarterly publication sounds acceptable and is within our capabilities.

As you can imagine, a magazine which doesn't have any advertising takes much longer to produce. It's very easy to slap together an issue which has 60% advertising and only 40% editorial.

And if the editorial is purely written copy, the task is even easier. Written copy is very easy to produce and although it may sound impressive, a good writer can churn out two or three pages in a day. It's when it comes to diagrams, photos and technical matter that the pace slows down.

Some of the pages, such as the programs for the Microcomp, represent 20 to 30 hours per page and it's nothing to see only 6 pages after a month's hard work. Maybe we aren't very fast but the daily requirements of running the business slows down the progress.

Because we have set our goals very high, we have suffered enormously. It has been our intention to keep the magazine relatively free of advertising and especially avoid breaking up the articles with meaningless ads. By this I mean the ones which tell you nothing about the product. Like lists of products and services, which never vary from one issue to the next. These are not my idea of excitement!

The other requirement is a regular publishing schedule. Up to now the issues have been released only when all the projects are tested and finalised.

Reader's don't want this. They want a monthly or bi-monthly journal or at least a known publishing date.

To this end we have decided upon a quarterly schedule and since we have a lot of projects ready for inclusion, we can see ourselves being very busy for many issues to come.



I think every person and every business gets hit with a shoddy purchase or workmanship at some time in their life and if we aired our grievances every time something went wrong, nothing would be bought.

But to know about someone else's bad dealings can be invaluable. It may save you falling into the same trap.

We hear about the extremes, from the man who sued an Australian match company for failing to supply 50 matches in the match-boxes, to the scrap metal dealer who was duped out of thousands of dollars by a con man offering to sell the Eiffel Tower for scrap!

Thousands of people are being tricked every day; paying for goods and never receiving them.

The prospective swimming pool owner who paid \$6,000 for a luxury pool and is still waiting for the hole to be dug, one year after paying the full price! Or the hundreds of Queensland farmers who paid for an electronic scarecrow which has yet to be delivered. And doesn't work anyway!!

With all this prior knowledge, we pride ourselves in knowing not to pay before delivery and thoroughly research a product before signing on the dotted line.

With this in mind, we offer you our latest lesson.

## THE COPIER THAT DIDN'T COPY.

Every month we get deluged with advertising literature for photocopiers.

After doing without, for a number of years, we decided to invest in one.

One thing we have learnt in the past is the need to buy a well-known brand. Without the backing of a reputable firm you could be in serious trouble in a few years, if repairs were required.

The sales pitch we were given in the leaflets and from phone calls we made was the enormous reliability of modern photo-copiers and the low cost per copy. Also the copy quality rivalled off-set printing and thus for runs up to 100 or so, a photocopier was the answer.

Obviously one-offs were exclusively the realm of the copier.

After researching the field thoroughly we decided upon a C - - - model 120. We cannot print the name but if you ring us, we will let you know. We asked every question in the book before signing on the dotted line - except one. The guarantee. Later we found out it was ONE MONTH!

When you consider how many photocopies an average office makes in one

month, it represents about 1 to 2 hours of operation!

Imagine if you sold a TV and quoted a guarantee of one hour!!

The management's answer to this was "The copier is only partly electronic and partly mechanical - you cannot compare the two."

You may not be able to compare the two but ONE MONTH is an indication of the faith they have in their product.

Within the guarantee period we were told the machine would be adjusted free of charge and so, within the 30 days, we phoned for a final adjustment.

This was duly done and had I not been present, we would have been charged \$45.00 for the call. Only under insistence did the serviceman ring his superior and cancel the invoice.

Throughout the next weeks and months the copy quality gradually deteriorated until one day JET-BLACK copies emerged.

Fortunately the service centre is just down the road and I hopped into my car and called into the 'Serviceman's Club Rooms.'

At first they said point-blank that I needed a service call and would not help me any way at all. When I said I had adjusted some of the controls and made no improvement, they started rambling on with the most amazing load of rubbish about what could be the cause.

After about 10 minutes I could see I wasn't getting anywhere and decided to go back home and call head office.

Getting past the 'front desk' was a feat in itself and to get a feasible explanation to the fault was way beyond the scope of any of the personnel.

In desperation I took the front cover off the copier and was confronted with a series of pots - none of which were identified and it was only by remembering the controls touched by the previous serviceman, that we got any clue at all.

Even full adjustment of each and every control produced little better than an extremely dark copy.

Accepting defeat I rang for a service call.

Quite soon we had the pleasure of a smartly dressed serviceman who saw the name TALKING ELECTRONICS on the door and thought "What a load of twits - I'll fix this!"

Faster than a rabbit down a hole, he had the cover glass off the machine and was merrily polishing the plate and lens system. Next he went to the corona wires and made them sing like a single string violin.

The excess toner container had a little in it and he promptly and eagerly dumped it onto a sheet of paper and wrapped the whole thing up like a 3 week old baby.

Then came the master's touch. He made a photocopy. Black as ink. Off came the cover. Fiddle, fiddle. Another copy. Black as ink. Out came the manual. Fiddle, fiddle. Another copy. Black again!

By now his quick, efficient antics had slowed and he made his first utterance: "I think the drum's gone." "Drums are on a pro-rata basis and a new one will cost xxx dollars."

Knowing I wouldn't be contributing a cent, I said "Go ahead." Half an hour later he had a new drum fitted and made a copy. Black as ever.

Now the chips were down. He wasn't as smart as he thought and started to talk to us.

I can't remember what he did next but about half an hour later he had changed the fluorescent tube which scans the page. Instant success. Copies came out perfectly.

It took about 30 minutes to replace the drum and adjust all the controls back to normal.

My point is this. Why did it take one hour and forty five minutes to locate the fault and then be charged nearly \$100 for the job?

When you call the manufacturer you expect the get expert service. Not to have someone learning at your expense.

Repairs are one of the hidden costs when operating a piece of sophisticated equipment and especially when a firm has a monopoly on servicing.

There is absolutely nothing you can do. If we refused to pay the bill, the serviceman said we would be black banned.

The story doesn't end here. There's a little more.

At the time when the tube was replaced, we asked about some streaks down the page. The reply was the toner roller was worn and would cost about \$120 to replace. He didn't look at the offending part and made no mention that it could be repaired.

At \$120 we weren't interested and let the stripes remain.

Gradually these got worse and when it came to the time when an important photocopy was required, I decided to look into the fault.

To my amazement the toner roller assembly came away via a couple of screws and two clips.

Upon inspection I noted some of the powder had hardened and built up on the magnetic roller. A little solvent and some

hard rubbing removed all signs of the build-up and when it went together, the copies were perfect.

Keeping quiet as to the remedy, I phoned the manufacturer and asked about the fault. I could get absolutely no further than 'a service call was necessary'.

Again I ask. Why didn't I get any assistance from either the servicemen or the service department?

If our experience is any indication of the treatment being offered by multi-national companies, it's no wonder they have a team of servicemen in each district.

If you are in the market to buy a copier, remember us. By the time you buy a machine, fill it with paper, toner and cough up for a few service calls, you will be better off going to the local chemist or library and paying 10c per copy!

## THE POST OFFICE . . .

Some people wonder why I am so critical of the Post Office.

They want me to be "all smiles and jovial" when taking the packets of mail and bags of publications to the counter.

But I have been around longer than most of them and seen an enormous decline in the service and an alarming increase in the ignorance towards the dissemination of the printed word.

I have seen postal rates increase from 1/2c per item to 30c per item in a period of time when wages have increased only about 400%. All along, the Post Office has maintained that the distribution of registered publications has been a LOSING proposition and with this they have increased the rates to an extent that they are choking the Australian publisher out of business.

Do you realize it costs more to post a magazine than to have it printed? Quite a ridiculous situation.

But there is nothing more absurd than the reasoning and intelligence of the personnel behind the decisions in the marketing and pricing sections of the Aust Post Monopoly.

For the privilege of getting reduced rates for registered publications, they charge a \$36.00 application fee each year! But the final straw broke last week when a parcel of publications cost MORE than a normal postal article. In fact to post large quantities of magazines interstate costs exactly the same as normal rates.

So much for the understanding of the spread of information.

For a face-to-face discussion over some of the anomalies I had the pleasure of seeing the Field Manager for our local area. After a few attempts to explain the why's and wherefore's of how the prices were generated, he came up with a comment that absolutely floored me.

"I don't see why you publishers should get cheaper rates anyway," he said.

Can you imagine how I reacted! With a certain amount of cool I said, "Do you read a lot?" "No." "Do you get any journals?" "No."

If this type of reasoning prevails in our glorious Post Office administration, heaven help us in the future. They have already tried to

squeeze the most out of the long-suffering customer, now they want to cripple him completely.

The Post Office has already lost many large contracts and they are in peril of losing many more.

They answer this with "some you lose, some you win," sort of attitude.

There are two further requirements of the Post Office for registered publications but they are so absurd you will only laugh.

I'll finish now, while I'm still smiling and leave you with some of the inside workings of our largest national monument.

Oh, by the way, I'M not allowed to sign the Editorial. They rang me 2 years ago and wasted half an hour of my time over this blatant disregard of the rules! You will notice I don't sign it any more. Take a look. See. I don't sign it any more. Aren't we obedient.

Last week we got a long letter to say the publication number must appear on the cover of the magazine. I don't want the cover filled up with junk inscriptions like this. But, as you know what bureaucracy can do, we have regrettably added the wording.

When you get this magazine, consider it a great privilege the Aust Post has condescended to handling it!

## CAUTION for NZ READERS:

While on the topic of letting you know what and how we think, I must relay the dissatisfaction readers have had with one or more of the New Zealand suppliers as recommended in previous issues.

I have received nothing but complaints from our readers. The following excerpts from a letter is typical:

"I wrote to the PC board supplier as suggested by you (NZ firm) for a TEC board and waited nearly 6 months! When it finally arrived the board had no overlay and no solder mask, even though it was the same price as if ordered from TE. It was really home-made!"

We have seen similar results from boards made in NSW. It had no overlay, no solder mask and no roll tinning! In fact it wasn't worth buying! If you compare ours to theirs, you will know what we mean.

Back to the NZ reader. After getting the board and sending for parts, it failed to work. So he rang us and asked if we could help. We said the TEC could be sent in for repair and it would be returned the same day. After picking himself up off the floor, he said he would do just that.

A few days later it arrived and was repaired. (I can't remember the fault). He rang to say he got it 3 days later and couldn't believe the service.

I don't like canning any firm but the NZ firms we recommended in previous issues have certainly not lived up to expectations.

I would be pleased to hear from them and get their side of the story.

cont. P.51.

... from P.20.

## PHONE DIALLER Part III

### EXPERIMENTING FURTHER

Phone dialler part III took about one week of part-time effort for Colin to write (He's not very quick!) and has been tidied and closed up for publication.

However there are a number of improvements that can be made to the program (apart from the auto re-dial extension). For instance, the first byte in the number table is not used and can be deleted, the **CP 0A** instruction at **09C6** is not valid, and a few others.

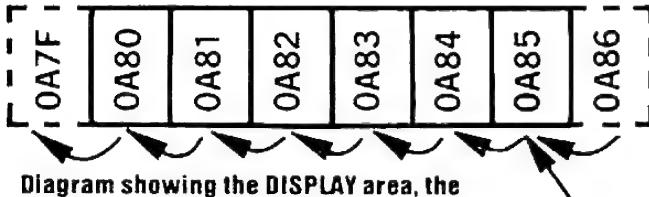


Diagram showing the DISPLAY area, the SHIFT procedure and address for NEW DATA.

These will be your challenge and at the same time see how you can simplify the program by using higher level commands. If you can't, don't worry. Programs in the next issue will be at a higher level and will use logic operations to create the same result with fewer instructions.

### SCROLL

LD A,FF	09C0	3E FF	Load A with FF and transfer to the I register to detect when a key has been pressed
LD I,A	09C1	ED 47	
LD A,I	09C4	ED 57	Look to see if a key has been pressed by comparing the accumulator with 0E. Return if the accumulator is 0E.
CP 0A	09C6	FE 0A	
NOP	09C8	00	
CP 0E	09C9	FE 0E	
RET Z	09CB	C8	
LD A,(HL)	09CC	7E	Load the value pointed to by HL into the accumulator
LD D,20	09CD	16 20	Load D with a short delay value (for below)
INC HL	09CF	23	Increment to the next location
CP 10	09D0	FE 10	Look to see if end of table reached
RET Z	09D2	C8	Return if end reached
LD (0A85),A	09D3	32 85 0A	Load the byte of the table into the display buffer
CALL SCAN	09D6	CD 80 09	Call SCAN for 32 loops (as determined by the D register)
DEC D	09D9	15	
JR NZ,09D6	09DA	20 FA	
CALL SHIFT	09DC	CD E1 09	Call SHIFT.
JR 09C4	09DF	18 E3	Jump to the start of the sub-routine

### SHIFT

LD B,07	09E1	06 07	Load B with 7
LD IX,0A7F	09E3	DD 21 7F 0A	Load IX with location one lower than display buffer
LD A,(IX + 01)	09E7	DD 7E 01	Load A with the value in the display buffer and transfer it to the next lower location
LD (IX + 00),A	09EA	DD 77 00	Increment the IX register
INC IX	09ED	DD 23	Dec B.
DEC B	09EF	05	and jump to above for 7 loops
JR NZ,09E7	09F0	20 F5	Return
RETURN	09F1	C9	

at 0A00:

### DISPLAY TABLE:

0 = EB	
1 = 28	The alphabet table on the right is used to produce the letters for the name. Two key
2 = CD	presses are required for each letter.
3 = AD	
4 = 2E	
5 = A7	
6 = E7	The display table on the left is used by the program to produce the digits of the phone
7 = 29	number. These hex values can also be used in conjunction with the alphabet table if you want
8 = EF	a digit to appear in the NAME.
9 = AF	
0 = EB	

A = 6F	N = 6B
B = E6	O = EB
C = C3	P = 4F
D = EC	Q = 3F
E = C7	R = 44
F = 47	S = A7
G = E3	T = 46
H = 6E	U = EA
I = 28	V = E9
J = E8	W = E1
K = 67	X = 26
L = C2	Y = AE
M = 65	Z = C9

## VIC-20 MAGAZINE

A letter from Cris Groenhout, Editor VIC-20 Magazine.

Despite the commercial demise of the very popular Commodore VIC-20 Colour Computer, there is still a great number of enthusiastic users remaining with absolutely no intention of disposing of their equipment. So, to support this large group of users, we have recently decided to continue publishing the Association's magazine 'VIC'.

'VIC' is now in its third year of publication with 16 bi-monthly issues under its belt. The magazine sells to subscribers and retail customers for \$2.00, a price which, compared to similar magazines, is very low. The magazine is also entirely dedicated to the VIC computer with no advertising and very little space tied up by news, letters, etc.

The association also distributes public domain software for a small copying fee and maintains a library of about 900 programs. There are also a number of other services and if you are interested in more information, write to Cris, at 25 Kerferd St., Watson, ACT, 2602. Tel: (062) 412 316, and enclose 2 stamps for return postage.

at 0A0C:                    at 0A2C:

E	C7	00	A7
N	6B	6B	4F
T	46	46	6F
E	C7	C7	C3
R	44	44	C7
00	00	00	84
I	28	6B	F
N	6B	6F	47
D	EC	65	00
E	C7	C7	C3
X	26	00	C2
00	00	00	C7
N	6B	6B	6F
o	E4	6F	C3
00	00	00	84
N	6B	6B	44
o	E4	6F	47
00	00	00	44
E	EB	44	44
00	00	00	47
3	AD	00	46
6	E7	00	44
00	00	00	44
P	4F	00	44
R	44	00	46
E	C7	00	46
00	00	00	4F
P	4F	00	44
R	44	00	46
S	A7	00	44
A	A7	00	46
00	00	00	44
P	4F	00	44
H	6E	00	46
O	EB	00	46
N	6B	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
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T	46	00	46
H	6E	00	46
E	C7	00	46
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N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
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o	E4	00	46
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T	46	00	46
H	6E	00	46
E	C7	00	46
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N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
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T	46	00	46
H	6E	00	46
E	C7	00	46
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N	6B	00	46
o	E4	00	46
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T	46	00	46
H	6E	00	46
E	C7	00	46
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N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
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N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
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T	46	00	46
H	6E	00	46
E	C7	00	46
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N	6B	00	46
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T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
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00	00	00	46
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o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	46
T	46	00	46
H	6E	00	46
E	C7	00	46
00	00	00	46
N	6B	00	46
o	E4	00	46
00	00	00	

## SUMMARY

THE FLIP FLOP FORMS THE BASIC ELEMENT OF THE SEQUENTIAL LOGIC CIRCUIT. THIS IS AN EXTREMELY VALUABLE BUILDING BLOCK AS IT POSSESSES:

1. MEMORY CAPABILITY
2. A DIVIDE BY TWO FEATURE

FLIP FLOPS CAN ALSO BE CALLED LATCHES, DIVIDERS OR MULTIVIBRATORS, DEPENDING ON HOW THEY ARE WIRED INTO A CIRCUIT.

THE MOST BASIC FLIP FLOP IS CALLED THE R-S FLIP FLOP. IT HAS 2 INPUTS CALLED S FOR SET & R FOR RESET. THE ONLY OTHER LINES ARE THE OUTPUT LINES. THESE ARE LABELED Q FOR THE NORMAL OUTPUT AND  $\bar{Q}$  (Q-BAR) FOR THE COMPLEMENTARY OUTPUT.

WHEN THE NORMAL OUTPUT IS HIGH, THE FLIP FLOP IS SAID TO BE SET. WHEN THE NORMAL OUTPUT IS LOW THE FLIP FLOP IS SAID TO BE RESET.

FLIP FLOPS NORMALLY HOLD DATA FOR A SHORT PERIOD OF TIME & THE R-S FLIP FLOP IS OFTEN CALLED AN R-S LATCH.

BUT THE R-S FLIP FLOP SUFFERS FROM ONE LIMITATION. IF BOTH INPUTS ARE HELD LOW THE OUTPUTS BOTH BECOME HIGH. THIS PRODUCES AN UNDESIRABLE RESULT AND THIS STATE MUST NOT BE ALLOWED TO OCCUR.

THE RESET - SET FLIP FLOP CAN BE USED TO DEBOUNCE A MECHANICAL SWITCH OR STORE DATA. IT IS AN ASYNCHRONOUS DEVICE AS THE OUTPUT CHANGES IMMEDIATELY THE INPUTS ARE ACTIVATED.

TO ACHIEVE A TIMING CONDITION A CLOCKED R-S FLIP FLOP HAS BEEN PRODUCED. THE INCLUSION OF A CLOCK LINE MEANS THE FLIP FLOP WILL NOT CHANGE UNTIL THE ARRIVAL OF THE CLOCK PULSE. — IT OPERATES SYNCHRONOUSLY. HOWEVER IT DOES POSSESS AN UNDESIRABLE OR PROHIBITED STATE WHERE BOTH OUTPUTS GO HIGH. TO OVERCOME THIS CONDITION A "D" LATCH HAS BEEN PRODUCED. THE D FLIP FLOP HAS AN INVERTER FITTED TO THE RESET LINE & FEEDS FROM THE SET LINE SO THAT THE TWO INPUTS ARE ALWAYS OUT-OF-PHASE.

AT THE TOP OF THE RANGE IS THE J-K FLIP FLOP. IT OVERCOMES ALL THE LIMITATIONS OF THE PREVIOUS TYPES. HOWEVER IT IS COMPLEX AND EXPENSIVE AND IS GENERALLY USED ONLY WHEN REQUIRED.

IT IS CAPABLE OF PERFORMING ALL THE OPERATIONS OF THE SIMPLER TYPES, AND MORE.

DEPENDING ON THE STATE OF THE INPUTS, THE OUTPUTS WILL PRODUCE 4 DIFFERENT EFFECTS:

1. FREEZE.
2. REMAIN OR CHANGE TO SET CONDITION
3. " " " RESET CONDITION.
4. TOGGLE.

THE TOGGLE FEATURE CAN BE USED TO PRODUCE A DIVIDE-BY-2 STAGE AND THE FLIP FLOP CAN BE CASCADED TO PRODUCE LONG LINES OF DIVISION STAGES. THESE SOON BECOME EFFECTIVE. WITH 7 STAGES THE DIVISION IS 128 AND 12 STAGES PRODUCES A DIVIDE-BY-4096 COUNTER.

THIS IS THE TOPIC FOR THE NEXT SECTION.



### QUIZ:

1. WHEN A LATCH IS STORING A BINARY 1 IT IS IN THE \_\_\_\_\_ (SET, RESET) MODE.
2. DRAW THE BLOCK DIAGRAM FOR AN R-S FLIP FLOP.
3. IF A FLIP FLOP IS RESET THE  $\bar{Q}$  OUTPUT IS \_\_\_\_\_ (HIGH, LOW)
4. THE NORMAL OUTPUT OF A FLIP FLOP IS  $Q, \bar{Q}$  \_\_\_\_\_.
5. FOR AN ACTIVE LOW R-S FLIP FLOP, SUPPLYING THE R LINE WITH A \_\_\_\_\_ (HIGH, LOW) WILL \_\_\_\_\_ (CLEAR, SET) THE Q OUTPUT TO A \_\_\_\_\_ (0, 1)
6. ASSUME AN R-S LATCH IS SET. A LOW TO THE S INPUT WILL:  
(a) DO NOTHING.  
(b) CHANGE THE FLIP FLOP TO RESET.
7. BOTH INPUTS OF A NOR LATCH ARE HIGH. THE STATE OF THE LATCH IS:  
(a) SET  
(b) RESET  
(c) UNDESIRABLE OR PROHIBITED  
(d) CAN'T TELL NOT ENOUGH INFORMATION
8. WHEN THE NIE LATCH IS IN THE "LIMBO" CONDITION BOTH OUTPUTS WILL BE: \_\_\_\_\_ (HIGH, LOW)
9.  $Q$  &  $\bar{Q}$  OUTPUTS SHOULD ALWAYS BE:  
(a) THE SAME  
(b) LOW  
(c) HIGH  
(d) COMPLEMENTARY.
10. STATE 2 USES FOR A LATCH:
11. COMPLETE THIS DIAGRAM OF A NAND GATE LATCH.  
A partial circuit diagram for a NAND gate latch. It shows a single input line labeled 'D' entering a NAND gate symbol. The output of the NAND gate is connected to a line labeled  $\bar{Q}$ .
12. A FLIP FLOP OPERATING IN STEP WITH A CLOCK IS SAID TO BE OPERATING:  
(a) SYNCHRONOUSLY.  
(b) ASYNCHRONOUSLY.
13. WHAT DOES "R-S" STAND FOR?

14. DRAW THE BLOCK DIAGRAM FOR A CLOCKED R-S FLIP FLOP:

23. LIST THE 4 SYNCHRONOUS MODES OF OPERATION OF THE J-K FLIP FLOP:

- A.
- B.
- C.
- D.

15. A CLOCKED R-S FLIP FLOP OPERATES:

- (a) ASYNCHRONOUSLY.
- (b) SYNCHRONOUSLY.

16. THE Q OUTPUT IS HIGH WHEN THE CLOCK IS \_\_\_\_ (HIGH, LOW) & THE SET OUTPUT IS \_\_\_\_ (HIGH, LOW) & THE RESET LINE IS \_\_\_\_ (HIGH, LOW)

17. THE  $\bar{Q}$  OUTPUT OF A D FLIP FLOP IS LOW. THE FLIP FLOP IS SAID TO BE IN THE \_\_\_\_ (SET RESET) STATE.

18. DATA AT THE D INPUT IS TRANSFERRED TO THE Q OUTPUT ON THE H-TO-L OR L-TO-H \_\_\_\_ TRANSITION OF THE CLOCK PULSE FOR A NAND GATE D FLIP FLOP.

19. FOR A D FLIP FLOP THE S&R LINES ARE ALWAYS:

- (a) HIGH
- (b) LOW
- (c) OUT-OF-PHASE.

20. THE CLOCK LINE DETERMINES THE STATE OF THE FLIP FLOP.

- (a) TRUE
- (b) FALSE.

21. WHY DOES A D FLIP FLOP HAVE AN INVERTER AT THE INPUT OF ONE LINE?

22. DRAW THE LOGIC SYMBOL FOR A J-K FLIP FLOP:

24. THE TWO INTERNAL SECTION OF A J-K FLIP FLOP ARE:

- (i)
- (ii)

25. NAME 2 FLIP FLOPS WHICH HAVE A CLOCK INPUT LINE:

- 1.
- 2.

26. THE OUTPUT STATE OF A J-K FLIP FLOP IS DETERMINED BY THE MASTER OR SLAVE LATCH?

27. IF THE  $\bar{Q}$  OUTPUT GOES HIGH-LOW-HIGH-LOW; THE FLIP FLOP IS IN WHAT MODE OF OPERATION? A:

28. A J-K FLIP FLOP IS CAPABLE OF PROVIDING A DIVISION. HOW MANY ARE REQUIRED TO PRODUCE A DIVIDE-BY-32.

29. IF THE J-K INPUTS ARE HIGH. WHAT IS THE MODE?

30. CAN THE J-K FLIP FLOP PRODUCE THE PROHIBITED OR UNDESIRABLE STATE?

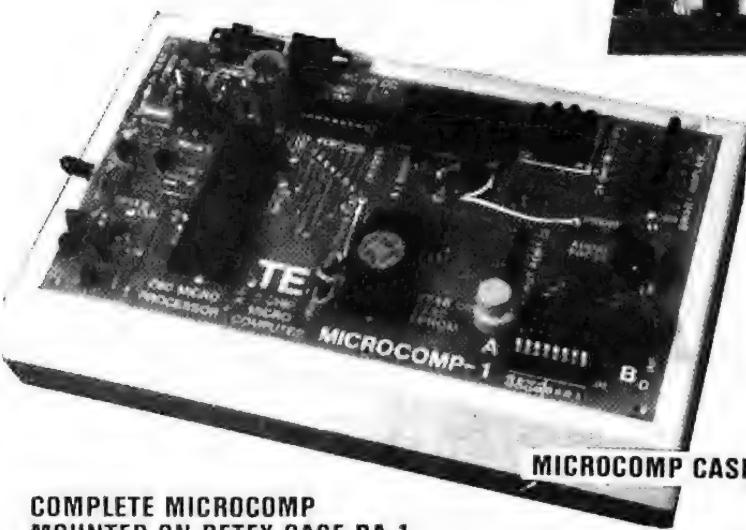
#### ANSWERS:

- 1. SET. 3. HIGH. 4. Q. 5. LOW, CLEAR, 0.
- 6.(a) 7.(c) 8. LOW 9.(d) 10. MEMORY, DIVISION, DEBOUNCE 12. (a) 13 RESET-SET. 15 (b)
- 16. HIGH, HIGH, LOW. 17. SET. 18. L TO H.
- 19. (c) 20 (b) 21. TO PRODUCE OUT OF PHASE S & R LINES. 23. HOLD, SET, RESET, TOGGLE.
- 24. MASTER LATCH, SLAVE LATCH. 25. D, J-K, CLOCKER R-S. 26. SLAVE. 27. TOGGLE.
- 28. 5. 29. TOGGLE 30. NO.

25/30 OR HIGHER IS EXCELLENT.

# MICRO COMP

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COMPLETE MICROCOMP  
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MICROCOMP CASE \$15.00

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PC Board: \$10.20  
Complete: \$59.95

This is the second article on the Microcomp and by now we have whet a lot of appetites.

Some constructors have gone way beyond that covered in the first article and investigated many of the remaining programs in the EPROM.

One constructor even listed the entire contents by using the LOOKING AT DATA routine at 0200. There were a couple of mistakes in his listing where he forgot to change from PROGRAM to DATA. This is one of the problems when trying to dissect a listing.

By now you will have some idea of how the bytes appear in EPROM. They come in a continuous string - without spaces or identification as to the beginning or end of a sequence. If you jump into the middle of a program and look at a byte, you will not know if it is an instruction, part of an instruction or a piece of data. That's why you must start at the beginning of a listing.

When trying to dissect a program, write down the values, byte by byte and you will soon see groups which you recognise. From there you can place the others in groups and start to see a program emerging.

These values are called MACHINE CODE values and are used by the micro directly. It doesn't need spaces or stops and starts as it is pre-programmed within and knows exactly what to do.

The difficulty you would experience in dissecting a program is understandable. You are not a micro and cannot keep track of the flow of the program. This is a very difficult direction to work in. The way we will be working is from IDEA-to-machine-code-listing. This is the forward direction and is much easier.

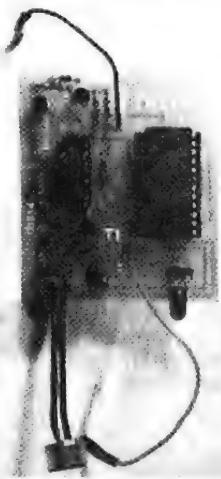
Most programs are made up of lots of small building blocks and the quickest way to learn about these is to study a few programs.

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Part I

TO BE RELEASED



MORSE TRAINER  
\$13.30 complete

In this article we will be continuing with a close study of each of the programs in the EPROM but before we do this we have designed a couple of games for those who want to do a little programming themselves.

If you have a TEC and either the non-volatile RAM or EPROM burner, these programs can be typed into memory and transferred to the microcomp for execution.

As designed, the programs are run at page ZERO however only a few changes are required and they can be run at any other location. The details of this are included with the programs.

The two games are titled: **TUG O' WAR** and **BLACK JACK**. Alongside each is a flow diagram showing what each part of the program does. Also we have explained each instruction with a simple sentence to show how we converted each idea into a computer instruction.

Getting back to the Microcomp, we have described a few more of the 'ins' and 'outs' of computer design and especially the tricks we used to simplify the circuit.

**Notebook No. 3** has just been released and it contains a number of pages on the Microcomp design as well as Z-80 Machine Code values for assembly and Disassembly. It also includes the interpretation of each instruction and a listing of computer terms. This will help you with programming and the circuit design pages will help you with input and output decoding and how the Z-80 communicates with all the other chips.

# TUG O' WAR &

# BLACK JACK

TWO programs for the MICROCOMP.

These two programs bring together the TEC computer, Non-volatile RAM and Microcomp. They show some of the techniques of displaying, inputting and running a program at a speed suitable for human involvement.

These games were developed on the above equipment and you can create similar programs or adapt them to suit your own requirements.

## TUG O' WAR

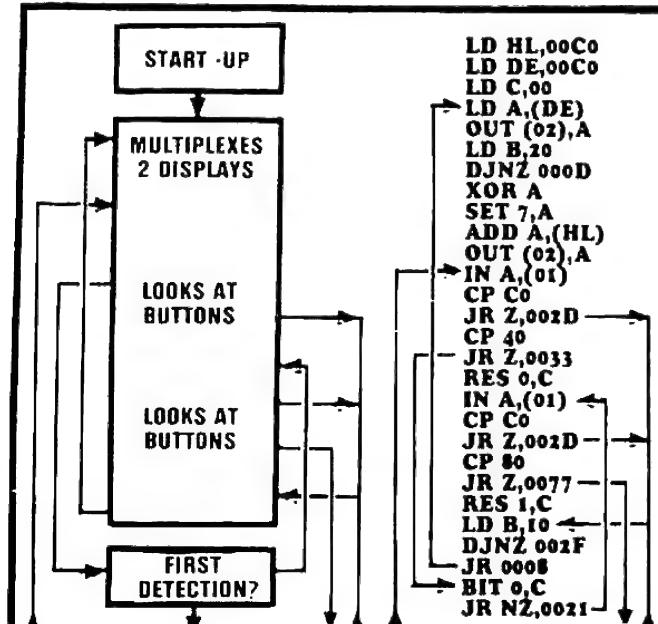
Instead of making a TUG O' WAR game from a kit, you can create an improved version by producing a program and running it on a computer.

Initially we saw this game in a popular electronics magazine and liked the way it worked.

It used a row of 15 LEDs and by pressing one of two buttons, a single illuminated LED would move towards you. Seven LEDs were available for each player and your opponent had the same opportunity to make the LED travel towards himself.

The difficulty of play could NOT be adjusted and a player would win whenever he pressed his button seven times more than his opponent.

## TUG O' WAR PROGRAM:



In our version, we have made it increasingly more difficult to reach the end by weighing the table of increments.

The lowest value has only one corresponding value in the table whereas the highest value requires nine steps before it will advance to WIN!

This can be seen by referring to the byte table and counting the number of bytes for each output value.

Not only does this program show you some new techniques in programming but will also save you a few dollars, if you already have the items mentioned above.

In a similar way, lots of other ideas and games can be produced and this will save you the expense of buying special PC boards and unusual chips.

Our version has nine steps and requires a total of 45 pushes for one player to win over his opponent.

This makes the game quite difficult and you have to introduce quite a lot of strategy to win

## DESIGNING THE PROGRAM

When designing a program, the first thing you have to consider is the hardware available. In our case this means the program has to be designed around two push buttons and two 7-segment displays. The row of 8 LEDs does not give us sufficient scope.

The two displays can be used to display numbers, letters, or individual segments. We opted to display the numbers 0-9.

The rest of the effect lies in the program.

This is how we went about designing it:

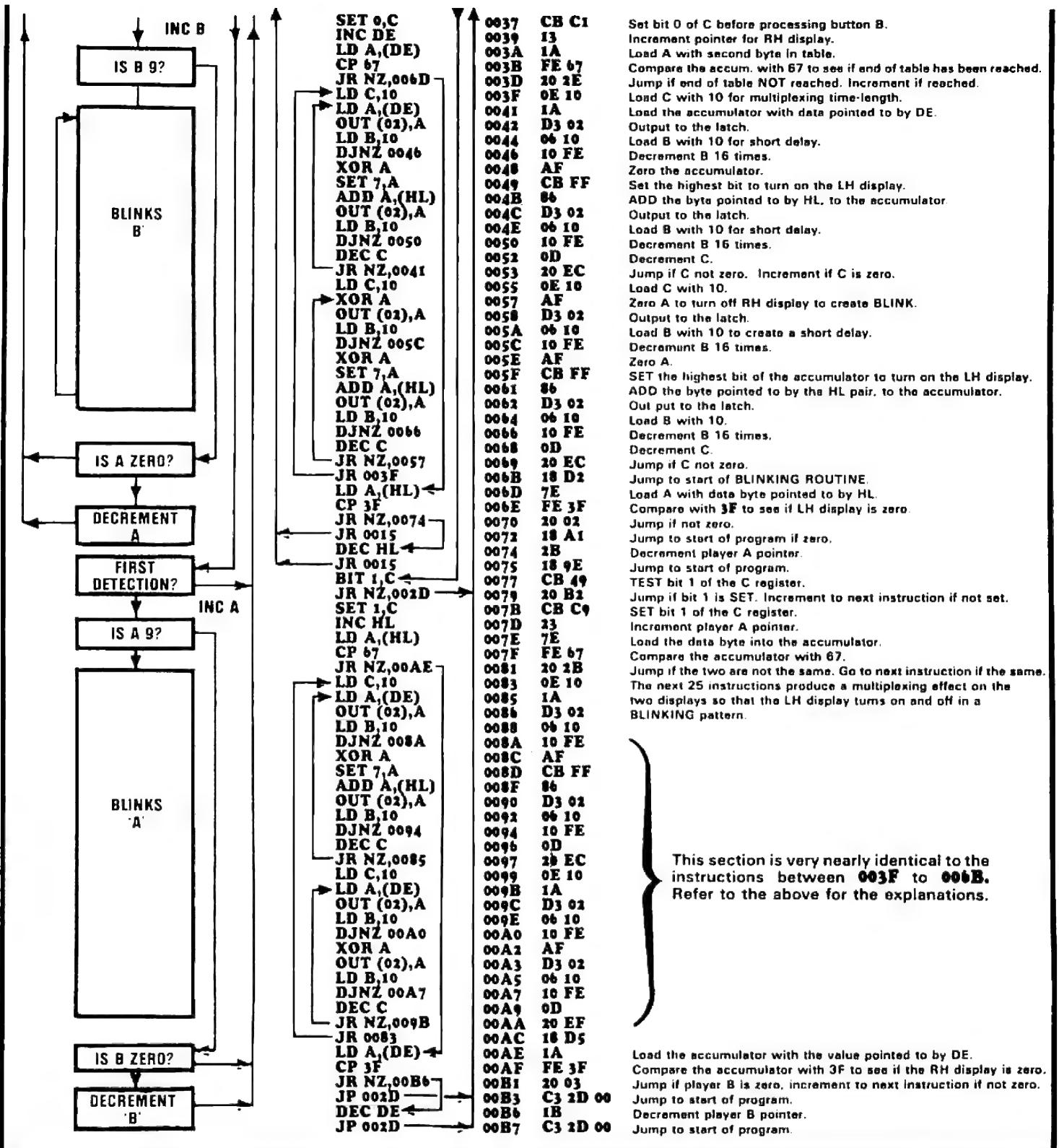
When the game starts, the two displays are illuminated with zeros. This requires a

cont. P. 62 . . .

The TUG O WAR program starts below and continues on the next page. It requires a table of 46 bytes for the display and this is placed at **00C0:**

AT C0:

3F	7D
06	7D
06	7D
5B	7D
5B	07
5B	07
4F	07
66	07
66	07
66	07
66	7F
66	7F
6D	7F
7D	7F
7D	7F
7D	67



loop in which the value for each display is looked after by a separate register pair. The left hand display is looked after by the HL register pair and the right hand display by the DE register pair.

This choice is governed by the fact that the HL pair has a larger number of op-codes available to us and thus it is more versatile.

You will see the need for this later.

Numbers produced on the right hand display can be created on the left hand display simply by turning on the highest line at the same time. This is done by adding '80' to the value of data. The same effect can be created by SETTING bit 7 of the accumulator and then ADDing the value of the right hand display. This is what we have done. The data required to produce a number in the right hand display has been added to the accumulator after the highest bit has been SET, with the result that the number appears on the left hand display.

Before this can be done, there is one point which must be remembered.

The accumulator must firstly be cleared so that all bits are zero. SETTING a bit and ADDing to the accumulator does not clear out any initial junk.

Using these facts, and a short DJNZ delay, will produce a loop program which will illuminate both displays.

Also in this loop we must include an instruction to look at the input port and detect 3 things:

We must detect if button A is pressed, button B and also if both buttons are pressed at the same time.

Detecting button A will cause the program to branch to a sub-routine, button B to another sub-routine and both buttons will cause the program to jump over the other branch-instructions.

When the micro jumps to either sub-routine, there are 4 instructions which must be taken into account.

Firstly it looks to see if it is the first time the sub-routine has been jumped to (during this press of the button). It does this by checking the debounce BIT in the C register. We must create a debounce condition so that the displays will increment only one byte in the table for each press of the button. This is achieved by resetting the BIT(s) in the C register while executing the main program. When a button is pressed, the micro goes to the sub-routine and looks at the particular bit in question.

If it is in a RESET state, the micro runs through the sub-routine and SETs the bit. It then increments the pointer register to look at the next byte in the table. It then compares the value with 67 to see if the end of the table has been reached. If it has, it goes to a loop program which flashes the winning display.

If the end of the table has not been reached, the program looks at the opposition value to see if it is zero. If it is zero, the micro returns to the main program. If the opposition is not zero, it decrements the pointer register and jumps to the main program.

The effect on the screen may or may not be an increment or decrement, depending on the position of the pointer registers, however you can be assured the byte table has been decremented and/or incremented correctly.

All you have to do now is put these facts into a machine code program.

When doing this, it is very helpful to use arrows to indicate where the program jumps to. You can also put labels and notes at various locations to indicate what the program is doing. This will assist you when debugging and tidying up.

Study the program on the previous 2 pages and see how it's done.



## BLACK JACK

This program is designed around Paul's Black Jack in issue 11.

The concept of the program is to deal a hand of random values exactly like playing cards.

It then keeps a tally of your hand and adjusts the total to your advantage when one or more ACES are dealt.



It is the feature of the Ace being equal to 1 or 11 which adds interest to the game and brings a little strategy into the program.

Apart from the normal requirements, the program must keep track of an ace. When one is included, BIT 7 of the C register is SET. The C register is our TEST REGISTER.

The computer keeps dealing cards until a value over 21 is reached. It then looks to see if an ace is included by testing BIT 7. If this bit is SET, it subtracts ten from the total, making the ace equal to one.

Further cards are dealt and once again a score is kept, in an attempt to reach 21.

When exactly 21 is reached, the program jumps to a routine which flashes '21' and at the same time looks at the input port for button B being pressed. If it is pressed, the program returns to the start.

The other important feature to remember when producing a program is TIMING. By this we mean the length of time for the things to be done, such as the numbers appearing on the screen.

If they appear for too short a duration, it will be annoying. A long duration will slow down the game.

These periods are controlled by a delay routine which is inserted into the program to 'waste computer time'.

The length of these delays depends on the clock speed and since we have a very slow clock frequency, we have delay routines to match.

Our maximum clock speed is 35,000 cycles per second so that if we waste 35,000 clock cycles, we produce a delay of 1 second.

The simplest way of producing a delay is to use DJNZ. The maximum DJNZ delay is produced by loading B with FF and this wastes  $13 \times 255$  cycles (3315 cycles) or about 1/10th sec. Longer delays can be obtained by using 2 DJNZ's and shorter delays by decreasing the value of B.

The other way to create a delay is to run through a loop which gradually decrements a delay value. This type of program is necessary when multiplexing is required.

The only way of obtaining a suitable value for the delay is to study some of the examples.

If you are unsure, insert '80' and trim the value during final testing. '80' represents a mid-value and you can increase or decrease it later.

## INDEXED ADDRESSING

Black Jack uses a table (located at the end of the program) which does three things. Firstly it determines the character to appear on the right hand display, then the character for the left hand display and finally the equivalent hex value.

This requires 3 bytes which we have grouped together to form a 'block'.

Even when the left hand display is not showing a value, it is being accessed with a zero output so that uniform illumination is produced when a value such as '10' is displayed.

To pick up the 2nd and 3rd byte in each group, we have used INDEXED ADDRESSING.

This is a handy way of jumping down a table without incrementing the register.

If you were to increment it, you would have to decrement it before the start of the next loop and this would involve extra instructions.

In our program, the register in charge of the table is incremented only after a multiplexing operation (which may involve a number of passes of a loop).

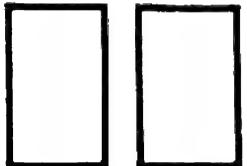
When the register is incremented, it is incremented 3 times so that it looks at the first byte of the next group. That is the 1st, 4th, 7th 10th byte etc.

The 2nd and 3rd bytes of each group are looked at via the indexing feature which uses a displacement value. For instance (IX + 01) looks at the second byte and (IX + 02) looks at the 3rd byte.

### RELOCATING THE PROGRAM

Although the program is designed for the Microcomp and to be run at page zero, it can be shifted to any other location by simply changing all the absolute address values.

**PLAYER 'A'    PLAYER 'B'**



**HL Register Bit 1,C    DE Register Bit 0,C**

The diagram shows the two displays and their associated register pair. The Debounce is done in register 'C'.

There are two main types of addressing. ABSOLUTE and RELATIVE. Relative values refer to locations by using a displacement value in the program and whenever the program is shifted, these values remain unchanged.

However absolute address values must be changed whenever a program is shifted as the values refer to specific locations.

In our program, the absolute values include the address of the tables and jumps which are over 80 hex bytes away. (Relative jumps can only cope with jumps less than 80 hex bytes away, in either direction).



The '5 CARD HAND' which wins if 21 is not obtained. Our program does not take this into account but it would be a simple matter to make it do so.

Here's the program. Type it on the TEC, hold it in the non-volatile RAM and play it on the Microcomp.

### At 0100:

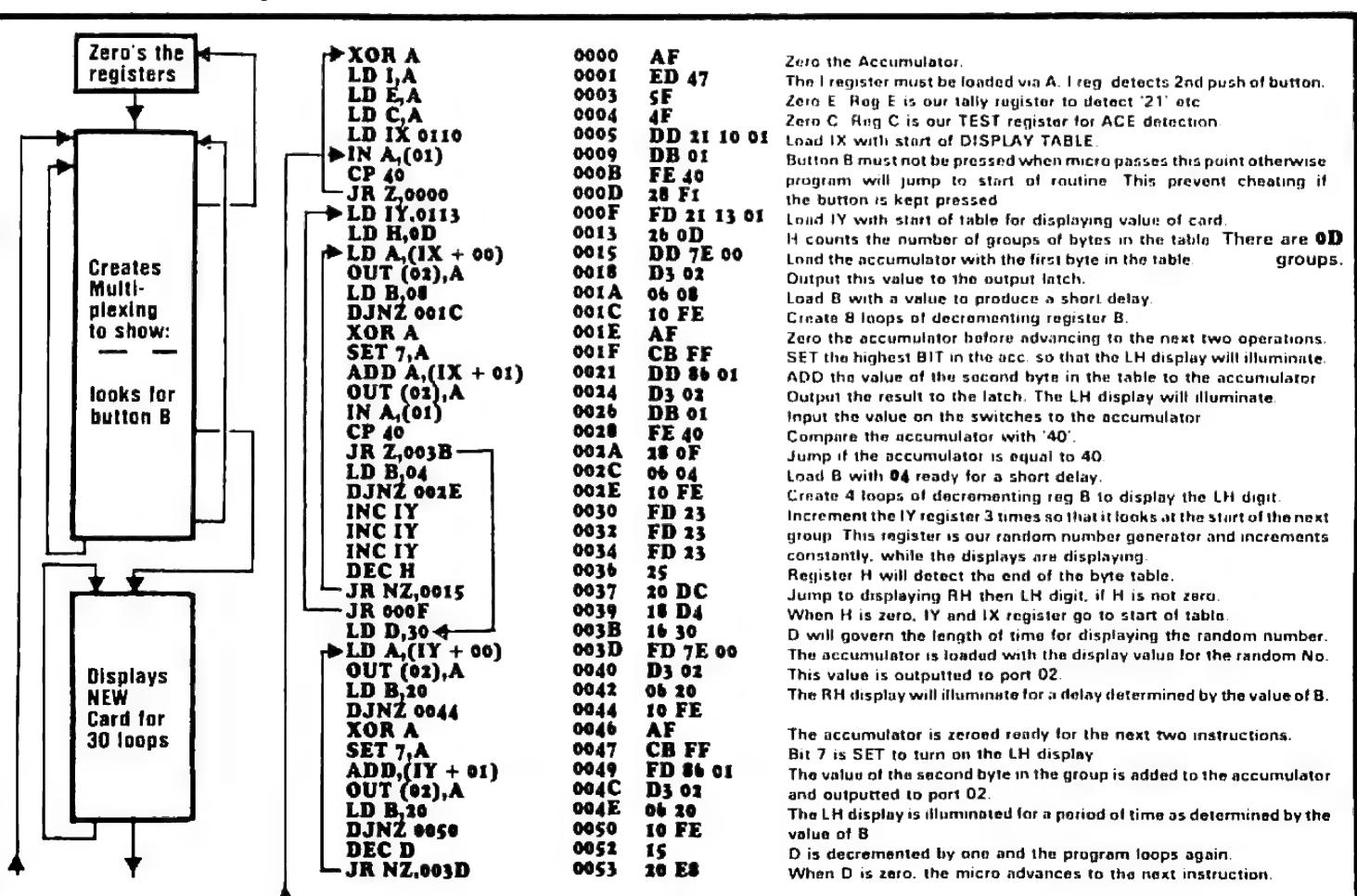
Each hex value produces a number from 0 to 9:

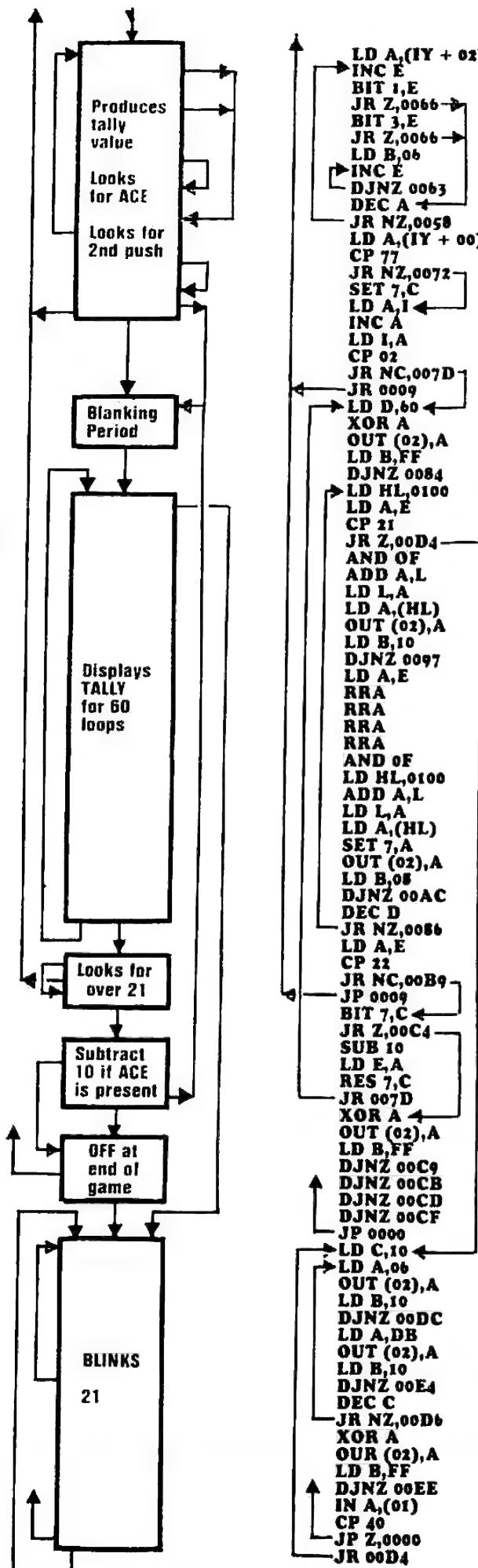
3F	0
06	1
5B	2
4F	3
66	4
6D	5
7D	6
07	7
7F	8
67	9

### At 0110:

The first two bytes produce the 'CARDS' and the third byte holds the value of the card.

40	-	7F	8
40	-	00	0
00		08	
5B	2	67	9
00		00	
02		09	
4F	3	77	A
00		00	
03		0B	
66	4	1E	J
00		00	
04		0A	
6D	5	3F	10
00		06	
05		0A	
7D	6	3F	10
00		06	
06		0A	
07	7	3F	10
00		06	
07		0A	





**LD A,(IY + 02)**

**INC E**

**BIT 1,E**

**JR Z,0066 →**

**BIT 3,E**

**JR Z,0066 →**

**LD B,06**

**DEC A ←**

**JR NZ,0058**

**LD A,(IY + 00)**

**CP 77**

**JR NZ,0072**

**SET 7,C**

**LD A,1 ←**

**INC A**

**LD I,A**

**CP 02**

**JR NC,007D**

**JR 0009**

**LD D,60 ←**

**XOR A**

**OUT (02),A**

**LD B,FF**

**DJNZ 0084**

**LD HL,0100**

**LD A,E**

**CP 21**

**JR Z,00D4**

**AND OF**

**ADD A,L**

**LD L,A**

**LD A,(HL)**

**OUT (02),A**

**LD B,10**

**DJNZ 0097**

**LD A,E**

**RRA**

**RRA**

**RRA**

**RRA**

**AND OF**

**LD HL,0100**

**ADD A,L**

**LD L,A**

**LD A,(HL)**

**SET 7,A**

**OUT (02),A**

**LD B,05**

**DJNZ 00AC**

**DEC D**

**JR NZ,0086**

**LD A,E**

**CP 22**

**JR NC,00B9**

**JP 0009**

**BIT 7,C ←**

**JR Z,00C4**

**SUB 10**

**LD E,A**

**RES 7,C**

**JR 007D**

**XOR A ←**

**OUT (02),A**

**LD B,FF**

**DJNZ 00C9**

**DJNZ 00CB**

**DJNZ 00CD**

**DJNZ 00CF**

**JP 0000**

**LD C,10 ←**

**LD A,06**

**OUT (02),A**

**LD B,10**

**DJNZ 00DC**

**LD A,DB**

**OUT (02),A**

**LD B,10**

**DJNZ 00E4**

**DEC C**

**JR NZ,00D6**

**XOR A**

**OUR (02),A**

**LD B,FF**

**DJNZ 00EE**

**IN A,(01)**

**CP 40**

**JP Z,0000**

**JR 00D4**

**0055 FD 7E 02**

**0058 INC E**

**0059 BIT 1,E**

**005A JR Z,0066 →**

**005B BIT 3,E**

**005C JR Z,0066 →**

**005D LD B,06**

**005E DEC A ←**

**005F JR NZ,0058**

**0060 LD A,(IY + 00)**

**0061 CP 77**

**0062 JR NZ,0072**

**0063 SET 7,C**

**0064 LD A,1 ←**

**0065 INC A**

**0066 LD I,A**

**0067 CP 02**

**0068 JR NC,007D**

**0069 JR 0009**

**0070 LD D,60 ←**

**0071 XOR A**

**0072 OUT (02),A**

**0073 LD B,FF**

**0074 DJNZ 0084**

**0075 LD HL,0100**

**0076 LD A,E**

**0077 CP 21**

**0078 JR Z,00D4**

**0079 AND OF**

**0080 ADD A,L**

**0081 LD L,A**

**0082 LD A,(HL)**

**0083 SET 7,A**

**0084 OUT (02),A**

**0085 LD B,10**

**0086 DJNZ 0097**

**0087 LD A,E**

**0088 RRA**

**0089 RRA**

**0090 RRA**

**0091 RRA**

**0092 AND OF**

**0093 LD HL,0100**

**0094 ADD A,L**

**0095 LD L,A**

**0096 LD A,(HL)**

**0097 SET 7,A**

**0098 OUT (02),A**

**0099 LD B,05**

**0100 DJNZ 00AC**

**0101 DEC D**

**0102 JR NZ,0086**

**0103 LD A,E**

**0104 CP 22**

**0105 JR NC,00B9**

**0106 JP 0009**

**0107 BIT 7,C ←**

**0108 JR Z,00C4**

**0109 SUB 10**

**0110 LD E,A**

**0111 RES 7,C**

**0112 JR 007D**

**0113 XOR A ←**

**0114 OUT (02),A**

**0115 LD B,FF**

**0116 DJNZ 00C9**

**0117 DJNZ 00CB**

**0118 DJNZ 00CD**

**0119 DJNZ 00CF**

**0120 JP 0000**

**0121 LD C,10 ←**

**0122 LD A,06**

**0123 OUT (02),A**

**0124 LD B,10**

**0125 DJNZ 00DC**

**0126 LD A,DB**

**0127 OUT (02),A**

**0128 LD B,10**

**0129 DJNZ 00E4**

**0130 DEC C**

**0131 JR NZ,00D6**

**0132 XOR A**

**0133 OUR (02),A**

**0134 LD B,FF**

**0135 DJNZ 00EE**

**0136 IN A,(01)**

**0137 CP 40**

**0138 JP Z,0000**

**0139 JR 00D4**

**0140 0055 FD 7E 02**

**0141 0058 INC E**

**0142 0059 BIT 1,E**

**0143 005A JR Z,0066 →**

**0144 005B BIT 3,E**

**0145 005C JR Z,0066 →**

**0146 005D LD B,06**

**0147 005E DEC A ←**

**0148 005F JR NZ,0058**

**0149 0060 LD A,(IY + 00)**

**0150 0061 CP 77**

**0151 0062 JR NZ,0072**

**0152 0063 SET 7,C**

**0153 0064 LD A,1 ←**

**0154 0065 INC A**

**0155 0066 LD I,A**

**0156 0067 CP 02**

**0157 0068 JR NC,007D**

**0158 0069 JR 0009**

**0159 0070 LD D,60 ←**

**0160 0071 XOR A**

**0161 0072 OUT (02),A**

**0162 0073 LD B,FF**

**0163 0074 DJNZ 0084**

**0164 0075 LD HL,0100**

**0165 0076 LD A,E**

**0166 0077 CP 21**

**0167 0078 JR Z,00D4**

**0168 0079 AND OF**

**0169 0080 ADD A,L**

**0170 0081 LD L,A**

**0171 0082 LD A,(HL)**

**0172 0083 SET 7,A**

**0173 0084 OUT (02),A**

**0174 0085 LD B,10**

**0175 0086 DJNZ 0097**

**0176 0087 LD A,E**

**0177 0088 RRA**

**0178 0089 RRA**

**0179 0090 RRA**

**0180 0091 RRA**

**0181 0092 AND OF**

**0182 0093 LD HL,0100**

**0183 0094 ADD A,L**

**0184 0095 LD L,A**

**0185 0096 LD A,(HL)**

**0186 0097 SET 7,A**

**0187 0098 OUT (02),A**

**0188 0099 LD B,05**

**0189 0100 DJNZ 00AC**

**0190 0101 DEC D**

**0191 0102 JR NZ,0086**

**0192 0103 LD A,E**

**0193 0104 CP 22**

**0194 0105 JR NC,00B9**

**0195 0106 JP 0009**

**0196 0107 BIT 7,C ←**

**0197 0108 JR Z,00C4**

**0198 0109 SUB 10**

**0199 0110 LD E,A**

**0200 0111 RES 7,C**

**0201 0112 JR 007D**

**0202 0113 XOR A ←**

**0203 0114 OUT (02),A**

**0204 0115 LD B,FF**

**0205 0116 DJNZ 00C9**

**0206 0117 DJNZ 00CB**

**0207 0118 DJNZ 00CD**

**0208 0119 DJNZ 00CF**

**0209 0120 JP 0000**

**0210 0121 LD C,10 ←**

**0211 0122 LD A,06**

**0212 0123 OUT (02),A**

**0213 0124 LD B,10**

**0214 0125 DJNZ 00DC**

**0215 0126 LD A,DB**

**0216 0127 OUT (02),A**

**0217 0128 LD B,10**

**0218 0129 DJNZ 00E4**

**0219 0130 DEC C**

**0220 0131 JR NZ,00D6**

**0221 0132 XOR A**

**0222 0133 OUR (02),A**

**0223 0134 LD B,FF**

**0224 0135 DJNZ 00EE**

**0225 0136 IN A,(01)**

**0226 0137 CP 40**

**0227 0138 JP Z,0000**

**0228 0139 JR 00D4**

**0229 0140 0055 FD 7E 02**

**0230 0141 0058 INC E**

**0231 0142 0059 BIT 1,E**

**0232 0143 005A JR Z,0066 →**

**0233 0144 005B BIT 3,E**

**0234 0145 005C JR Z,0066 →**

**0235 0146 005D LD B,06**

**0236 0147 005E DEC A ←**

**0237 0148 005F JR NZ,0058**

**0238 0149 0060 LD A,(IY + 00)**

**0239 0150 0061 CP 77**

**0240 0151 0062 JR NZ,0072**

**0241 0152 0063 SET 7,C**

**0242 0153 0064 LD A,1 ←**

**0243 0154 0065 INC A**

**0244 0155 0066 LD I,A**

**0245 0156 0067 CP 02**

**0246 0157 0068 JR NC,007D**

**0247 0158 0069 JR 0009**

**0248 0159 0070 LD D,60 ←**

**0249 0160 0071 XOR A**

**0250 0161 0072 OUT (02),A**

**0251 0162 0073 LD B,FF**

**0252 0163 0074 DJNZ 0084**

**0253 0164 0075 LD HL,0100**

**0254 0165 0076 LD A,E**

**0255 0166 0077 CP 21**

**0256 0167 0078 JR Z,00D4**

**0257 0168 0079 AND OF**

**0258 0169 0080 ADD A,L**

**0259 0170 0081 LD L,A**

**0260 0171 0082 LD A,(HL)**

**0261 0172 0083 SET 7,A**

**0262 0173 0084 OUT (02),A**

**0263 0174 0085 LD B,10**

**0264 0175 0086 DJNZ 0097**

**0265 0176 0087 LD A,E**

**0266 0177 0088 RRA**

**0267 0178 0089 RRA**

**0268 0179 0090 RRA**

**0269 0180 0091 RRA**

**0270 0181 0092 AND OF**

**0271 0182 0093 LD HL,0100**

**0272 0183 0094 ADD A,L**

**0273 0184 0095 LD L,A**

**0274 0185 0096 LD A,(HL)**

**0275 0186 0097 SET 7,A**

**0276 0187 0098 OUT (02),A**

**0277 0188 0099 LD B,05**

**0278 0189 0100 DJNZ 00AC**

**0279 0190 0101 DEC D**

**0280 0191 0102 JR NZ,0086**

**0281 0192 0103 LD A,E**

**0282 0193 0104 CP 22**

**0283 0194 0105 JR NC,00B9**

**0284 0195 0106 JP 0009**

**0285 0196 0107 BIT 7,C ←**

**0286 0197 0108 JR Z,00C4**

**0287 0198 0109 SUB 10**

**0288 0199 0110 LD E,A**

**0289 0199 0111 RES 7,C**

**0290 0199 0112 JR 007D**

**0291 0199 0113 XOR A ←**

**0292 0199 0114 OUT (02),A**

**0293 0199 0115 LD B,FF**

**0294 0199 0116 DJNZ 00C9**

**0295 0199 0117 DJNZ 00CB**

**0296 0199 0118 DJNZ 00CD**

**0297 0199 0119 DJNZ 00CF**

**0298 0199 0120 JP 0000**

**0299 0199 0121 LD C,10 ←**

**0300 0199 0122 LD A,06**

**0301 0199 0123 OUT (02),A**

**0302 0199 0124 LD B,10**

**0303 0199 0125 DJNZ 00DC**

**0304 0199 0126 LD A,DB**

**0305 0199 0127 OUT (02),A**

**0306 0199 0128 LD B,10**

**0307 0199 0129 DJNZ 00E4**

**0308 0199 0130 DEC C**

**0309 0199 0131 JR NZ,00D6**

**0310 0199 0132 XOR A**

**0311 0199 0133 OUR (02),A**

**0312 0199 0134 LD B,FF**

**0313 0199 0135 DJNZ 00EE**

**0314 0199 0136 IN A,(01)**

**0315 0199 0137 CP 40**

**0316 0199 0138 JP Z,0000**

**0317 0199 0139 JR 00D4**

**0318 0199 0140 0055 FD 7E 02**

**0319 0199 0141 0058 INC E**

**0320 0199 0142 0059 BIT 1,E**

**0321 0199 0143 005A JR Z,0066 →**

**0322 0199 0144 005B BIT 3,E**

**0323 0199 0145 005C JR Z,0066 →**

**0324 0199 0146 005D LD B,06**

**0325 0199 0147 005E DEC A ←**

**0326 0199 0148 005F JR NZ,0058**

**0327 0199 0149 0060 LD A,(IY + 00)**

**0328 0199 0150 0061 CP 77**

**0329 0199 0151 0062 JR NZ,0072**

**0330 0199 0152 0063 SET 7,C**

**0331 0199 0153 0064 LD A,1 ←**

**0332 0199 0154 0065 INC A**

**0333 0199 0155 0066 LD I,A**

**0334 0199 0156 0067 CP 02**

**0335 0199 0157 0068 JR NC,007D**

**0336 0199 0158 0069 JR 0009**

**0337 0199 0159 0070 LD D,60 ←**

**0338 0199 0160 0071 XOR A**

**0339 0199 0161 0072 OUT (02),A**

**0340 0199 0162 0073 LD B,FF**

**0341 0199 0163 0074 DJNZ 0084**

**0342 0199 0164 0075 LD HL,0100**

**0343 0199 0165 0076 LD A,E**

**0344 0199 0166 0077 CP 21**

**0345 0199 0167 0078 JR Z,00D4**

**0346 0199 0168 0079 AND OF**

**0347 0199 0169 0080 ADD A,L**

**0348 0199 0170 0081 LD L,A**

**0349 0199 0171 0082 LD A,(HL)**

**0350 0199 0172 0083 SET 7,A**

**0351 0199 0173 0084 OUT (02),A**

**0352 0199 0174 0085 LD B,10**

**0353 0199 0175 0086 DJNZ 0097**

**0354 0199 0176 0087 LD A,E**

**0355 0199 0177 0088 RRA**

**0356 0199 0178 0089 RRA**

**0357 0199 0179 0090 RRA**

**0358 0199 0180 0091 RRA**

**0359 0199 0181 0092 AND OF**

**0360 0199 0182 0093 LD HL,0100**

**0361 0199 0183 0094 ADD A,L**

**0362 0199 0184 0095 LD L,A**

**0363 0199 0185 0096 LD A,(HL)**

**0364 0199 0186 0097 SET 7,A**

**0365 0199 0187 0098 OUT (02),A**

**0366 0199 0188 0099 LD B,05**

**0367 0199 0189 0100 DJNZ 00AC**

**0368 0199 0190 0101 DEC D**

**0369 0199 0191 0102 JR NZ,0086**

**0370 0199 0192 0103 LD A,E**

**0371 0199 0193 0104 CP 22**

**0372 0199 0194 0105 JR NC,00B9**

**0373 0199 0195 0106 JP 0009**

**0374 0199 0196 0107 BIT 7,C ←**

**0375 0199 0197 0108 JR Z,00C4**

**0376 0199 0198 0109 SUB 10**

**0377 0199 0199 0110 LD E,A**

**0378 0199 0199 0111 RES 7,C**

**0379 0199 0199 0112 JR 007D**

**0380 0199 0199 0113 XOR A ←**

**0381 0199 0199 0114 OUT (02),A**

**0382 0199 0199 0115 LD B,FF**

**0383 0199 0199 0116 DJNZ 00C9**

**0384 0199 0199 0117 DJNZ 00CB**

**0385 0199 0199 0118 DJNZ 00CD**

**0386 0199 0199 0119 DJNZ 00CF**

**0387 0199 0199 0120 JP 0000**

**0388 0199 0199 0121 LD C,10 ←**

**0389 0199 0199 0122 LD A,06**

**0390 0199 0199 0123 OUT (02),A**

**0391 0199 0199 0124 LD B,10**

**0392 0199 0199 0125 DJNZ 00DC**

**0393 0199 0199 0126 LD A,DB**

**0394 0199 0199 0127 OUT (02),A**

**0395 0199 0199 0128 LD B,10**

**0396 0199 0199 0129 DJNZ 00E4**

**0397 0199 0199 0130 DEC C**

**0398 0199 0199 0131 JR NZ,00D6**

**0399 0199 0199 0132 XOR A**

**0400 0199 0199 0133 OUR (02),A**

**0401 0199 0199 0134 LD B,FF**

**0402 0199 0199 0135 DJNZ 00EE**

**0403 0199 0199 0136 IN A,(01)**

**0404 0199 0199 0137 CP 40**

**0405 0199 0199 0138 JP Z,0000**

**0406 0199 0199 0139 JR 00D4**

**0407 0199 0199 0140 0055 FD 7E 02**

**0408 0199 0199 0141 0058 INC E**

**0409 0199 0199 0142 0059 BIT 1,E**

**0410 0199 0199 0143 005A JR Z,0066 →**

**0411 0199 0199 0144 005B BIT 3,E**

**0412 0199 0199 0145 005C JR Z,0066 →**

**0413 0199 0199 0146 005D LD B,06**

**0414 0199 0199 0147 005E DEC A ←**

**0415 0199 0199 0148 005F JR NZ,0058**

**0416 0199 0199 0149 0060 LD A,(IY + 00)**

**0417 0199 0199 0150 0061 CP 77**

**0418 0199 0199 0151 0062 JR NZ,0072**

**0419 0199 0199 0152 0063 SET 7,C**

**0420 0199 0199 0153 0064 LD A,1 ←**

**0421 0199 0199 0154 0065 INC A**

**0422 0199 0199 0155 0066 LD I,A**

**0423 0199 0199 0156 0067 CP 02**

**0424 0199**

Before we continue our dissection of the program for the Microcomp, let us pause for a discussion on a number of related topics. These will help you to understand how a micro system goes together and how it functions.

### PROGRAMMING THE 2732.

The 2732 in the Microcomp kit comes ready programmed with a set of experimental programs and only the lower half of the ROM has been filled.

This leaves the upper half vacant, for use in any way you wish.

There are two ways in which the upper half can be filled. One is by using an EPROM programmer and burning the locations yourself. The other is to write the program and have someone else burn the ROM.

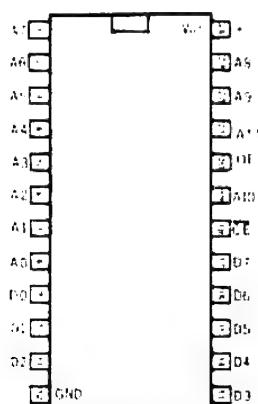
Burning a program is only done after you are thoroughly satisfied with its performance, as it is very difficult (if not impossible) to change the program, once it is burnt. For this reason it is best to get the program up and running via a medium which can be easily altered, as a program quite often has to go through lots of changes and modifications before you are completely satisfied.

The most logical way is to use some form of RAM memory, in which the locations can be altered as many times as you like. The only difficulty with RAM memory is it will lose its contents when the power is switched off. If the RAM is backed up with a battery, the contents will be retained.

This arrangement can then be used to generate programs without the fear of loss, should the computer be turned off.

The program can then be transferred from the programming computer to the Microcomp.

The Microcomp sees each half of a 2732 as a separate 2k block of memory.



The program-accessing routine at 0000 must be written for both the lower half and upper half and this will enable you to start at any address, providing it is an even hex value.

Burning can be carried out on the TEC EPROM BURNER and full details of this project can be found in issue 13.

Memory is divided into PAGES and each page consists of 256 bytes. When programming, all address values are written in hexadecimal form and one page contains FF bytes. See P. 16 of issue 11 for the hex table and details on understanding hex notation. A 1k block of memory has 4 pages and a 2k memory chip such as 2716 has 8 pages. A 4k memory chip such as 2732 will hold 16 pages of bytes.

A program can range from only a few bytes to many pages and to give you an idea of the compactness of machine code, the two previous games, TUG O' WAR and BLACK JACK, occupied about 1 page each. Obviously a more complex game with a more complex display (such as a video screen) would require more instructions but one page has the capacity to hold about 100 instructions.

This means a 2k ROM will hold about 8 simple programs.

Programs are not fast to be produced and it may take 10 to 50 hours to create a one-page program. A 2k ROM may take weeks or even months to fill!

Once you are satisfied with the performance of a program, you are ready to burn it into an EPROM.

Before this can be done there are two things you should do.

Firstly you should determine where you are going to place the program. This is important as it will be in a different location to where it was being created and the absolute address values will not apply.

Often the program is created at address 0000 and all jump instructions relate to this. Any address values which have been defined are called absolute and must be changed when the program is shifted to a new location.

When you have determined the new location, you should BLOCK TRANSFER the program to the same address in the non-volatile RAM, using the following program:

at 0C00:  
**11** \_\_\_\_\_ TO: address + 1000H  
**21** \_\_\_\_\_ From: address + 1000H  
**01** \_\_\_\_\_ No of bytes.  
**ED B0**  
**C7**

For example, if you have produced a 148 byte program at 0000 in the non-volatile RAM and need to shift it to 0280, here is the Block Transfer program:

at 0C00:      **11 B0 12**  
**21 00 10**  
**01 48 01**  
**ED B0**  
**C7**

### At the beginning of the RAM you need a jump routine:

```
06 00
DB 01
21 00 00
6F
29
29
29
E9
```

This is entered at 0000 in the non-volatile RAM, which is ADDress 1000 on the TEC (to access the start of the expansion port socket)

Now you must change all the absolute address values (such as the start of a table, a jump instruction etc.)

Change the switch on the non-volatile RAM card to 'ROM' and switch the TEC off. Transfer the non-volatile RAM to the Microcomp and load '28' on the input switches. Turn the comp on and push reset. The program will run.

You should now remove all traces of the lower program so that you are sure the new one is the only one being run. This is done on the TEC by loading FF into each location of the old program

The program is now ready for transfer to EPROM. You have confirmed its operation and run it at its new location - nothing more need be done.

Refer to the EPROM BURNER project in issue 13 for the actual transfer procedure.

When you have completed a program and burnt it into EPROM, it should be fully documented by writing it out as shown in our examples.

It is important to use arrows to indicate the jumps and even a block diagram explaining what is happening at various locations.

A description of the program including which buttons are doing what, will also help as it's very easy to forget how the game is played, after a few months.

Give the program a name and fill out the log below to assist in identification.

If you follow these rules you will be able to use parts of the program when creating new ideas and save generating everything afresh.

Sw. Positions:	Address:	Name of Program:

## RAM and ROM

RAM is the abbreviation for RANDOM ACCESS MEMORY.

It is temporary storage memory in which data is only retained while the power is applied.

When the power is removed, the contents are lost. This is because data is stored via a flip flop or single MOS transistor and these require power (although very little) for the data to be retained.

There are two forms of Random Access Memory. **STATIC** and **DYNAMIC**.

Static Memory uses a flip flop for each bit of information and this will hold the HIGH or LOW as long as the power is connected to the chip.

Dynamic Memory uses only a single MOS transistor in which a charge on a substrate indicates the presence of data. Since this charge has the tendency to leak away, it must be replenished every 2 milliseconds. This requires additional circuitry and is inconvenient in a small system; although it is the cheapest way to purchase blocks of memory.

RAM is also called Read/Write memory as it can be written into and read during the process of executing a program.

A micro system which does not have any RAM is called a dedicated system and is limited to running a program contained in ROM memory.

The need for RAM varies enormously with the task. Sometimes you only need a few bytes of RAM to store temporary values and the same locations can be written into again and again.

Otherwise you need a large amount of RAM to store a whole screen of information.

With as little as one page (256 bytes) a system can be designed to perform quite complex tasks as the data can be updated and written-over constantly.

The Z-80 requires only two very small sections of RAM for it to become a 'thinking' computer. These two areas are called SCRATCHPAD and STACK.

The scratchpad or BUFFER zone needs only a few bytes where such data as displays values are kept. This frees registers for carrying out program commands.

The other area is STACK and this is where bytes are loaded (in pairs) so that the contents of a particular register can be saved. The stack is unusual in that it grows downwards as more bytes are added and it is essential to keep removing bytes at the same rate as they are added so that the stack does not grow too large.

The other peculiar feature about the stack is the access you have to its contents. It is a LAST-ON FIRST-OFF arrangement and only the top byte (and the next) is

accessible and this is another reason for keeping the stack manageable.

The main purpose of the STACK is to free registers for other operations and then be able to re-load them with the value that had been saved.

Our Microcomp does not have RAM memory and thus the stack and scratch-pad features are not available.

The alternative to scratch-pad is to use a register pair to hold 2 bytes of data and this has been done in many of the programs. This severely limits programming as the working registers are held-up as memory cells.

Without a stack, programs have to be designed differently and may take more programming steps, but they work just as well.

IX, IY, HL and DE register pairs and also the alternate A, BC, DE and HL registers can be used to get around the storage problem.

Some of the programs for the Microcomp show how the registers have been used in this way.

## ROM

ROM is Read Only Memory

This memory is used to store instructions which do not have to be altered. Data in ROM remains fixed and stable, even when power is removed. It is permanent.

There are different types of ROM memory. One is programmed by the manufacturer and cannot be changed, the other is erasable memory and can be programmed by the client. It can also be erased if the contents are not required, by exposing to ultra violet light for about 15 minutes.

In the Microcomp project, a 2732 EPROM has been used. This is the most economical size for the job and is capable of holding 4k of information. 4k is equivalent to 4096 bytes and would be a very long program if it contained a single program!

If we assume an instruction takes an average of 2 bytes, the program will extend for 2048 lines! A program of this length would take many weeks to produce and the number of things it could do would be quite impressive.

In the Microcomp, the 2732 is accessed in two halves. This is done via a jumper. The lower half contains a range of programs which we are currently investigating and by taking the jumper lead to the lower pin on the PC board, the upper half of the EPROM is accessed.

The upper half is blank and you can fill it with programs of your own. The first 10H bytes must contain a jump routine identical with the lower half to allow you to jump to the start of each program.

In the near future you will be able to send in your EPROM for filling with additional routines. The programs for the 'add-ons'

will be loaded into the upper half and many of these are already finalized. But firstly we want to fully explain the lower half and get you acquainted with the concepts.

One question we have been asked is why the Microcomp has only 11 address lines whereas the 2732 requires 12!

The answer is we are creating the 12th address line via the jumper lead. When the 12th line is LOW, the lower 2k is accessed. When the jumper is HIGH, the upper 2k is accessed. Since this is a manual operation, a program cannot cross the 2k border and routines in the lower half cannot be accessed by those in the upper section. (If you wish to cross the 2k boundary, place the jumper on A11).

Because of our arrangement, the 2732 can be considered as two separate 2k blocks, each of which is equivalent to a 2716 EPROM. In fact you can use 2716's without the need for any modifications.

Each 2k block is addressed in hexadecimal notation. It starts at 0000 and goes to 0FFF. The next 2k starts at 0800 and finishes at 0FFF. There are 8 pages in 2k and those are Page 0, 1, 2, 3, 4, 5, 6 and 7. Each page contains FF bytes as explained previously.

All address values, data values and Jump Relative values are Hex values and you need to think in HEX notation when writing Machine Code programs.

Using the Microcomp will familiarize you with hex and encourage you to think in this notation.

## BASIC vs MACHINE CODE

Everyone has heard much about BASIC. It introduced many of us into the world of microcomputers and it deserves its reputation for being the best language for teaching computers to beginners.

And true enough, Basic has enabled beginners to perform tasks which would have been absolutely impossible otherwise.

But basic isn't the solution to all programming. When you need a simple program for sequencing or timing, you don't need basic. When you need high-speed graphics, you don't use Basic. And when you want to design your own system, you can't include Basic.

In fact you don't use any high level language at all. You use only the codes which the microprocessor understands; and these are called MACHINE CODES.

That's the language or instruction set we are teaching: MACHINE CODE or MACHINE CODE PROGRAMMING.

With Machine Code you can perform all the operations and effects available to the Basic programmer except you have to create them all yourself.

Remember that all the work and skill put into compiling the set of Basic instructions would represent years of effort and we would never be able to attain this level of development via a simple model.

For us, we will have to be satisfied with starting at the beginning and learning some of the simplest forms of programming. Even these will achieve an amazing variety of effects and you will be quite impressed with the results.

We are not rubbishing Basic but let's say it is completely removed from the field we are covering. Machine code is up to 10,000 times fast and takes up to 500 times less memory. But Most impressive is a Machine code system can be created without any external assistance. You become the master - designing your own system and only requiring a list of Machine code instructions for you to be able to complete anything from a sequencer to a robot.

## HOW TO START PROGRAMMING

All programs start with an idea. The idea may be vague at first or you may be lucky enough to know exactly what you want to achieve.

Vague or concrete, the way to start programming is by getting a sheet of paper and jotting down notes.

Start with sketches, scribbles and bits of data.

Put a date on the sheet and think up a name for the project. Names and labels help identify and strengthen your ideas.

These jottings will look feeble when you look back on them, but at the beginning they form the groundwork on which to build. It's the only positive way of getting the facts together.

Put down all you know and all you want to do, then go away and sort it over in your mind.

Your brain can actually put things together much better after you have cleared it first by writing down all the preliminaries.

Don't be afraid to use paper. It will take about 6-10 pages to produce one page of finished work.

At first the best idea is to use parts of existing programs and modify them to suit. Later you can think about creating complete programs of your own.

Lastly, don't be disappointed if the program doesn't work first go. We have trouble with all of ours. They rarely work first time.

But that's the wonderful part about programming. The micro picks up your mistakes and fails to operate.

When this happens, you can spend hours trouble-shooting the fault.

The best advice in this situation is to give the program to a friend acquainted with programming and ask him to check it. A fresh mind is more able to spot a silly mistake.

If you don't have anyone in this category, you will have to work through it yourself.

If the displays fail to light up, you will not know how far through the program the processor has gone.

Start at the beginning and look for the first OUT command. Immediately after this instruction place a HALT command. This will let you know if the micro has travelled this far through the program.

If the display still fails to light up, you will have to investigate each of the steps and instructions very carefully. Work backwards through the program using the DISASSEMBLY codes on the back of issue 12 (and also in Notebook No 3) and make sure you get the same instructions as in the original production of the program.

Next check the JUMP and JUMP RELATIVE values to confirm that the microprocessor is actually landing on the address intended. Read the section on Jump Relative in issue 12 of TE, because these are the trickiest bytes to add to a program. Remember, they are the LAST bytes to be inserted as you need to count the number of bytes between the present address and the address to be jumped to.

\*\*\*\*\*  
**Machine Code programming allows you to create your own system - with pen, paper and op-codes.**  
\*\*\*\*\*

When creating a program, you will not know the value of a displacement byte initially and it is important to put a line in place of the byte thus: \_\_\_\_\_ so that it can be inserted later. This line lets you know that one byte must be counted when working out the displacement values.

If the display still fails to illuminate, you can create your own display value by loading the accumulator and outputting it to the display and then adding a HALT instruction. This is a last resort! and lets you know how far the program is progressing.

I hope you don't have troubles of this complexity but if so, this will get you out.

Start with simple programs and get your ideas flowing. It's not as difficult as you think to convert ideas into visual effects and its very rewarding to see them running.

When writing a program for the Microcomp, you start at address 0000. This is where the processor naturally starts when the reset button is pressed.

It can then be shifted to a higher location and a jump routine used to access it.

Creating a program which RUNS takes a certain amount of skill. By 'runs' we mean it completes one pass of the program and displays the appropriate information on the displays. After you get it to run you can concentrate on adjusting the values of timing to achieve the most pleasing effects.

But the main problem is getting the program to run and we have already mentioned how to get into the program and force it to display. There are a couple of other points which we forgot to mention and they involve the placing of tables.

Tables should be placed well away from the program so that you don't run out of room. When everything works perfectly, they can be moved up and the pointers changed accordingly.

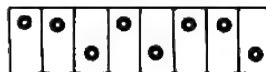
The idea is to get everything into a compact block and relative addressing uses less bytes than absolute addressing, so use it whenever possible. . Also remove any NOPs and any holes or spaces. Closing up a program and neatening it up takes time but it makes it much more presentable in the end.



We will now continue with the programs in the monitor, explaining each and every instruction and how the program is intended to work.

## FROM INPUT PORT TO 8 LEDs

This routine is located at 0290 and is addressed by switching the switches ON thus:



This program is very handy for checking the operation of the computer in the early stages. This may be too late for some constructors, but for those with a problem in the displays, it will help locate the fault.

The program checks each line of the input port and outputs it to the displays.

Each time you turn an input switch ON, the corresponding LED, in the row of 8 LEDs, will be illuminated.

If this does not happen, you can trace through the particular line and locate the fault.

The program at 0290 contains 6 bytes. That's all, just 6 bytes! It inputs the data on the input port and loads it into the accumulator. It then outputs it to port 2 to turn on the appropriate LEDs and then jumps back to the start of the program.

This means it is rapidly looping around the program and will update the displays as soon as the input values are changed.

The program can also be used to compare between the row of 8 LEDs, the 7-segment display(s) and the 4x4 matrix.

Experiment by inputting a hex value and see the effect you get on each of the displays.

In this way you can create any effect you want on the 4x4 (within limits).

### FROM INPUT PORT TO 8LEDs

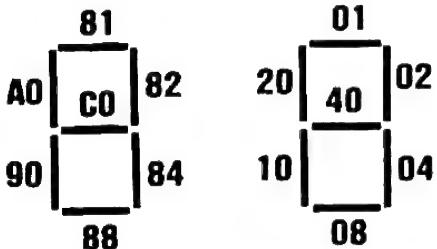
**IN A,(01)** 0290 **DB 01** Looks at input switches and places the value in the accumulator  
**OUT (02),A** 0292 **D3 02** Outputs accumulator to the latch  
**JR 0290** 0294 **18 FA** Jumps to start of program.

From this program you will see:

1. The value of each LED in the row of LEDs corresponds to a switch. The lowest value is 01, then 02, 04, 08, 10, 20, 40, 80, and this can be confirmed by the values written on the PC board.

2. The value of each switch also corresponds to a segment in the 7-segment display. Turn on various switches and see the effect(s).

Prove the following:



Adding '80' to a value will make the display jump to the 10's display. Note that 80 by itself does not turn on ANY display.

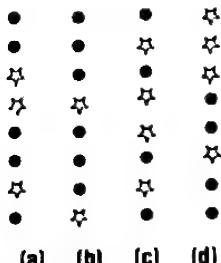
Button 'A' is connected to 80 and will make the figures jump from one display to the other.

3. The 4x4 matrix has been wired so that each column is turned on by a LOW value. These values are: 01, 02, 04, and 08. This will cause all the LEDs to come on. Each of the rows can be turned OFF and this is done via the values 10, 20, 40 and 80.

There are some limitations as to what combinations of LEDs can be turned on and this is something you must be aware of.

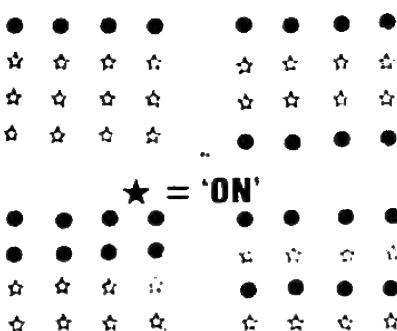
### Experiments:

Create these effects by using the input switches:



(a) (b) (c) (d)

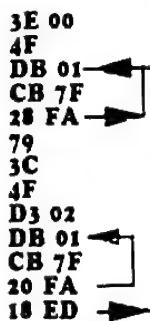
Create these effects on the 4x4 matrix:



This will enable you to see the effects on the display without having to manually input values via the switches.

The accumulator is required for two functions. It outputs the value of the count and then looks to see if a switch is pressed. That's why we need another register to hold the value of the count, so that the accumulator can be loaded with other information. Thus the C register has been used for temporary storage.

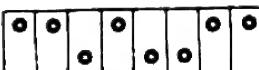
The program contains two small loops and the micro is constantly executing the top one when button A is not pressed and the lower one when the button is pressed. The micro jumps from one loop to the other during the time when the button is travelling from one state to the other.



This is a very simple way of creating a debounce condition and prevents more than one count being registered on each press of the button.

### AUTO INCREMENT (fast)

This program is located at 02C0 and lets you sit back and watch the displays



increment automatically. You will be interested to know that the program takes 256 steps before it repeats!

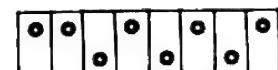
Compare the effect on the row of 8 LEDs with the 4x4 and seven segment displays.

Notice that they produce entirely different effects due to the placement of the LEDs and this can be remembered when designing displays for advertising etc

<b>LD A,00</b>	02C0	3E 00
<b>INC A</b>	02C2	3C
<b>OUT (02),A</b>	02C3	D3 02
<b>DJNZ 02C5</b>	02C5	10 FE
<b>DJNZ 02C7</b>	02C7	10FE
<b>DJNZ 02C9</b>	02C9	10 FE
<b>JR 02C2</b>	02CB	18 F5

### INCREMENT via BUTTON A

This program at 02A0 increments the display each time button A is pressed.



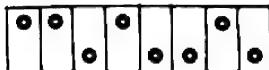
<b>LD A,00</b>	02A0	3E 00
<b>LD C,A</b>	02A2	4F
<b>IN A,(01)</b>	02A3	DB 01
<b>BIT 7,A</b>	02A5	CB 7F
<b>JR Z 02A3</b>	02A7	28 FA
<b>LD A,C</b>	02A9	79
<b>INC A</b>	02AA	3C
<b>LD C,A</b>	02AB	4F
<b>OUT (02),A</b>	02AC	D3 02
<b>IN A,(01)</b>	02AE	DB 01
<b>BIT 7,A</b>	02B0	CB 7F
<b>JR NZ 02AE</b>	02B2	20 FA
<b>JR 02A3</b>	02B4	18 ED

Load the accumulator with zero.  
Load zero into C.  
Input the value on the switches to the accumulator.  
Test BIT 7 of the accumulator to see if button A is pushed.  
Jump to 2A3 if NOT pressed. Go to 2A9 when pressed.  
Load C into the accumulator.  
Increment the accumulator.  
Load the answer into the TALLY register 'C'.  
Output the accumulator to the displays.  
Input the switches to the accumulator.  
Test BIT 7.  
Jump to 2AE if A is pressed. Go to 2B4 when released.  
Jump to 2A3.

The first instruction loads the accumulator with zero. You will notice this address is not used again by the program. Thus we call it a START-UP value. The accumulator is then incremented on each pass of the program and the value outputted to the latch. The next three instructions are DJNZ's in which the B register is decremented to zero during each instruction. After the 3 DJNZ's the program jumps to 02C2 and outputs the next higher value.

#### AUTO INCREMENT (variable)

This program is located at 02D0 and the speed with which the computer



02D0

completes one cycle depends on the setting of the input switches.

LD D,01	02D0	16 01
IN A,(01)	02D2	DB 01
LD C,A	02D4	4F
LD A,D	02D5	7A
OUT (02),A	02D6	D3 02
DEC C	02D8	0D
JR NZ 02D8	02D9	20 FD
INC D	02DB	14
JR 02D2	02DC	18 F4

'D' is the tally register and holds the value to be displayed on the screen, so that the accumulator can be used for other things.

'C' is the delay register and it is decremented very similar to a DJNZ statement, where FF produces the longest delay and 01 the shortest delay.

This is not quite correct, however, as you will find out for yourself.

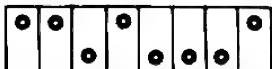
Load the value 01 and compare it with 00. 00 is a much longer delay and it appears to be as long as FF! In fact this is the case! The longest delay is produced when a register is loaded with 00 since the first operation to be performed on the register is to decrement it. The result is FF and that's why it takes FF loops to bring it to zero.

The program is designed to start with an output value of 01 and increment automatically to FF. The ON time (the delay time) is adjustable via the setting on the input switches.

Note: We don't have any control over the values appearing on the screen, just the speed of the increment.

#### AUTO DECREMENT

By changing one byte of the program at 02C0, we produce a decrementing



02E0

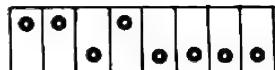
counter. The best effect of decrementing can be seen on the 8 LEDs. Adjust the speed control to view the effect in slow motion.

#### AUTO DECREMENT

LD A,00	02E0	3E 00	Load the accumulator with zero.
DEC A	02E2	3D	Decrement the accumulator.
OUT (02),A	02E3	D3 02	Output the accumulator to the latch.
DJNZ 02E5	02E5	10 FE	Decrement register 'B', FF loops.
DJNZ 02E7	02E7	10 FE	" " "
DJNZ 02E9	02E9	10 FE	" " "
JR 02E2	02EB	18 F5	Jump to start of program.

#### AUTO DECREMENT (variable)

This routine is located at 02F0 and decrements the display when button A is pressed. It has a fixed rate of decrementing and is not variable.



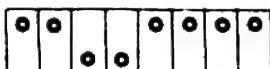
02F0

LD E,FF	02F0	1E FF	Load the COUNT HOLD register with FF.
LD A,E	02F2	7B	Load the Count Hold register into the accumulator.
OUT (02),A	02F3	D3 02	Output the accumulator to the latch.
DJNZ 02F5	02F5	10 FE	Create a short delay with the B register.
IN A,(01)	02F7	DB 01	Input the bank of switches to the accumulator.
Bit 7,A	02F9	CB 7F	Test bit 7 of the accumulator to see if A is pressed.
JR Z,02F2	02FB	28 F5	Jump to 02F2 if it is not pressed. Go to next line if pressed.
DEC E	02FD	1D	Decrement register E.
JR 02F2	02FE	18 F2	Jump to 02F2.

Load the TALLY register with 01  
Input the switch value to the accumulator.  
Load the accumulator into 'C' for the delay value.  
Load the TALLY into the accumulator.  
Output the tally value to the displays.  
Decrement register C  
Jump to 02D8 if register C is not zero  
Increment the tally register.  
Jump to the start of the program.

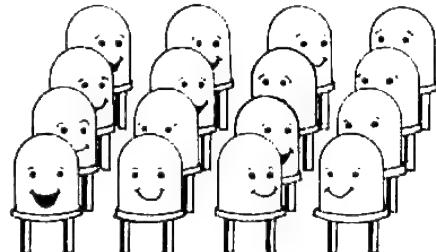
## 4x4 DISPLAY

As the name suggests, the program at 0300 is designed for the 4x4 DISPLAY. It



0300

will produce almost no interpretable effects on either of the other displays.



The routine we have presented is only just the start of what you can do with a set of LEDs in an array. Our 4x4 can be multiplied-up many times to produce an enormous array of LEDs or globes and obviously the ultimate is to produce a video screen with coloured globes to duplicate a TV. But the cost of this kind of venture is enormous as the parts alone would cost a fortune and the time taken to wire it up would be too much for an individual constructor.

That's why we have concentrated on a manageable module.

One of the decisions you have to make when outputting to LEDs, is the method of turning them ON. One is to connect each output of a latch directly to a LED. The other is to multiplex the display and scan it. The multiplex method uses the least number of chips and is obviously the cheaper.

The relative merits of each will be covered in future articles and for the moment we will study the effects which can be produced with a display connected in MULTIPLEX mode.

The program at 0300 is an OUTPUT ROUTINE in which a value is loaded from a table into the accumulator and outputted to the display. The display remains illuminated for a delay period and then the next byte is picked up from the table. This is done until all the bytes have been used.

When the end of the table is reached, the program starts again. This is repeated for 8 loops and then the micro advances to the second part. This is identical to the first except for the byte table. It has entirely different values and the effect is completely different. At the conclusion of the second byte-table, the micro jumps back to the start of the program and the first pattern is outputted.

The speed of presenting a pattern is controlled by the clock and the inbuilt delay value. The delay is fixed but the clock can be adjusted to slow-down or speed-up the effect.

→ LD B,08	0300	06 08	B is the COUNT REGISTER for the number of loops in the first program
→ LD HL,0338	0302	21 38 03	Load HL with the address of the start of the BYTE TABLE
LD C,18	0305	0E 18	Load C with the number of bytes for the program (There are 24 bytes)
→ DEC C	0307	0D	Decrement the number of bytes remaining in the table to detect the end of table
JR Z,0318	0308	28 0E	If no bytes remain, decrement the number of loops and start program again
LD A,(HL)	030A	7E	Load the accumulator with the byte pointed to by the HL register pair
OUT (02),A	030B	D3 02	Output this value to port 2
INC HL	030D	23	Increment HL to point to the next byte in the table
LD DE,0080	030E	11 80 00	Load DE with a short delay value.
→ DEC DE	0311	1B	Decrement DE
LD A,D	0312	7A	Load D into A.
OR E	0313	B3	Logically OR the accumulator with E to see when BOTH D and E are zero
JR NZ,0311	0314	20 FB	Jump to 0311 if the answer is NOT ZERO
JR 0307	0316	18 EF	Jump to DEC C and repeat for the second byte in the table
DJNZ 0302	0318	10 E8	Decrement the number of loops and start the byte table again
LD B,08	031A	06 08	Load B with 8 for the second part of the program
→ LD HL,0350	031C	21 50 03	
LD C,20	031F	0E 20	
→ DEC C	0321	0D	
JR Z,0332	0322	28 0E	
LD A,(HL)	0324	7E	
OUT (02),A	0325	D3 02	
INC HL	0327	23	
LD DE,0080	0328	11 80 00	
→ DEC DE	032B	1B	
LD A,D	032C	7A	
OR E	032D	B3	
JR NZ, 032B	032E	20 FB	
JR 0321	0330	18 EF	
DJNZ 031C	0332	10 E8	
JR 0300	0334	18 CA	

This part is identical with that above  
except the byte table is longer and  
located at a different address. When  
8 loops of this part have been  
executed the program jumps to the  
top program and the cycle repeats.

At 0338:      At 0350:

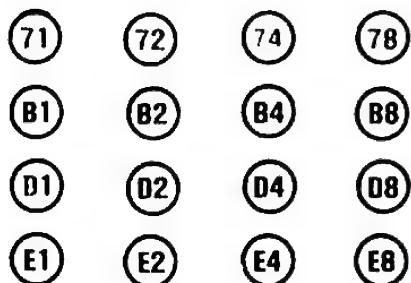
01	CF	0F	B8	D4
02	3F	FF	D8	D2
04	CF	0F	E8	B2
08	3F	FF	E4	B4
EF	96	0F	E2	D4
DF	FF	FF	E1	D2
BF	96	0F	D1	B2
7F	FF	FF	B1	B4
03	33	71	71	
0C	CC	72	72	
03	C3	74	74	
0C	3C	78	B4	

An almost unlimited number of patterns and effects can be produced on the 4x4. However not every combination can be displayed due to the limitations of how the LEDs are accessed.

This means you will have to learn how to access the LEDs and get the patterns you want.

To turn on a LED, the cathode end must be taken to earth and the anode to positive.

This is the hex value required to illuminate an individual LED:



To access the LEDs we have separated the output latch into two halves with the 4 lower bits connected to the anodes and the 4 upper bits to the cathodes.

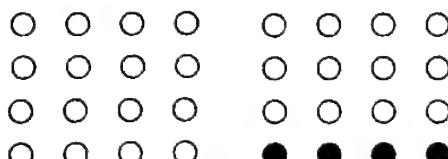
The following diagrams give you the values required to turn ON one or more LEDs:

ALL ON "0F"  
ALL OFF "FF" or "00".

#### LEGEND:

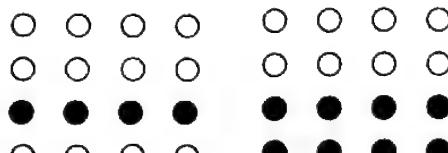
○ = ON.

● = OFF.



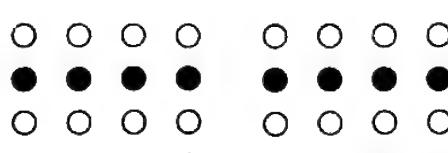
OF

1F



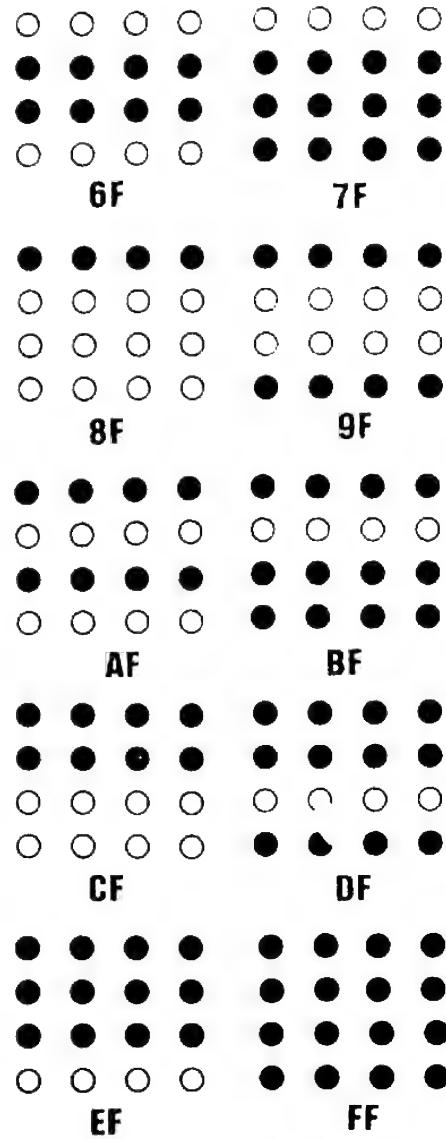
2F

3F



4F

5F



If you don't want all the LEDs in a row to be illuminated, refer to the diagrams on this page for the hex value needed to illuminate an individual column or column(s).

To use these values select from the first 16 diagrams to give the row(s) and from the following 16 diagrams for the column(s).

01	02
03	04
05	06
07	08
09	0A
0B	0C
0D	0E

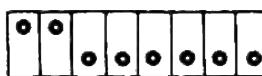
00  
00  
00  
00  
OF

When the two diagrams are placed on top of each other, the LEDs that are common to both, will be illuminated. Due to the sinking and sourcing limitations of the output latch, all the LEDs in the 4x4 can not be illuminated at the same time.

Brightness can be improved by turning off the 7-segment display by shorting the base and emitter leads of the driver transistor together with a jumper lead. This transistor is directly below the second display and is the middle transistor.

#### VERY LONG DELAY

This routine, at **03F0**, is particularly unusual. Not only is it a very long duration



delay but it shows that a program can be split up and placed in two different parts of memory, and still run.

And this is what we have done.

Half the program is located at **03F0** and the other half at **045A**. This makes the Micro jump up and down in ROM as it executes the program.

The jumping back and forth does not occupy many clock cycles but it does increase the overall time by about 5%.

We calculated the time delay to be so long that you may never see the display increment! This is due to the low clock speed. At 70kHz, the Z-80 is operating far below its normal rate and a delay like this introduces many millions upon millions of clock cycles.

#### WHY DO WE NEED DELAYS?

Delays are very important in micro programs. Due to the high speed of the execution of machine code

LD A,01	03F0	3E 01
LD I,A	03F2	ED 47
LD DE,FFFF	03F4	11 FF FF
LD HL,FFFF	03F7	21 FF FF
DEC HL	03FA	2B
LD A,H	03FB	7C
OR L	03FC	B5
JP 045A	03FD	C3 5A 04

instructions, some parts of the program must be slowed down so that humans can be involved. This may be for the video aspect, so that the eye can see what is being outputted on a display or for the audio side, so that we can detect tones and beeps.

Delays are also needed to give a SUSPENSE EFFECT for games of chance or strategy to give the impression that the computer is taking time to think.

Or for a video game, to create rates-of-movement for objects moving across the screen.

The delays we are talking about are PROGRAM DELAYS or SOFTWARE DELAYS. They are produced when the micro 'wastes time'. The simplest way of wasting time is to fill a register pair with a large number and gradually decrement it to zero.

By decrementing a single register, the maximum number of loops which can be executed is 256. Each loop may take 20 clock cycles and at the normal running frequency of a system (about 1MHz), the delay time will be very short. By using a REGISTER PAIR, the time can be increased 256 times. The delay becomes more noticeable and will be about 2 seconds.

If we require longer delays we can add another register-pair and increase the delay to more than 131,000 seconds!

When the system is operating at only 70kHz, the delay time turns into hours, days and months!

There is one point to note here: When a micro is performing a very long delay, the entire computer time is being taken up with a COUNT DOWN sequence and this means the micro will not be updating information on the displays or looking at the input port.

If you require other operations to be attended to, they must be included in the loop, as can be seen in the clock program at **0630**.

Segment 'A' will illuminate after a delay period.  
Save the 'TALLY' in the I register (Not part of IX)  
Load DE with the maximum value  
Load HL with the maximum value  
Decrement HL  
Load register H into the accumulator  
Logically OR the accumulator with L  
Jump to address **045A**.

JP NZ,03FA	045A	C2 FA 03
DEC DE	045D	1B
LD A,D	045E	7A
OR E	045F	B3
JP NZ,03F7	0460	C2 F7 03
LD A,I	0463	ED 57
OUT (02),A	0465	D3 02
INC A	0467	3C
LD I,A	0468	ED 47
JP 03F4	046A	C3 F4 03

If register H and L are not zero, jump to **03FA**.  
When HL (the inner loop) is zero, decrement DE.  
Load register D into the accumulator.  
Logically OR the accumulator with register E.  
If result is not zero, JUMP to **03F7** and DEC HL!  
When both HL and DE are zero, time is UP!  
Load the TALLY register into A and output it.  
Increment A.  
Load the new tally into the TALLY register.  
Load the register pairs and start again!

When we use two register pairs to create a very long time delay, we do not place one pair after the other as this would only double the time delay. We place them ON TOP of each other so that the effect is MULTIPLICATION. This means one pair is INSIDE the other and we say it is HIDDEN or NESTED. This arrangement gives rise to the term NESTED LOOP. This is what we are creating in this section.

The simplest method of increasing the delay is to add the instruction: **10 FE**. This will have the effect of adding 256 cycles to the delay time. This is a **DJNZ** instruction and operates with the **B** register. The advantage of a **DJNZ** is it does not affect the accumulator. In the Microcomp we do not have any RAM and we cannot save the accumulator via a PUSH operation since we do not have any STACK. Thus it's an advantage not to alter the contents of the accumulator.

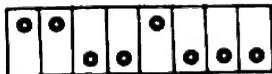
**DJNZ** loops are not nested loops but are additive and require the **B** register to be zero at the start of the delay routine to create the longest delay. At the end of a **DJNZ** the **B** register is zero and this is ideal for the next **DJNZ**.

**DJNZ**'s can be grouped thus:

<b>DJNZ FE</b>	<b>10 FE</b>

## 0 - 9 COUNTER

The first counter we are going to study is a 0-9 UP COUNTER. This is located at address **0370** and will show us how to



output numbers onto the display and how the INCrement operation is performed.

The main fact to remember with the program is the computer is NOT adding numbers. It is simply going through a table of values and it is the values it fetches that create the increments on the screen.

The table could be designed to produce letters or symbols and we would lose the effect of incrementing.

## 0 - 9 COUNTER

<b>LD C,0A</b>	<b>0370</b>
<b>LD DE,03DF</b>	<b>0372</b>
<b>IN A,(01)</b>	<b>0375</b>
<b>BIT 7,A</b>	<b>0377</b>
<b>JR Z,0375</b>	<b>0379</b>
<b>INC DE</b>	<b>037B</b>
<b>LD A,(DE)</b>	<b>037C</b>
<b>OUT (02),A</b>	<b>037D</b>
<b>IN A,(01)</b>	<b>037F</b>
<b>BIT 7,A</b>	<b>0381</b>
<b>JR NZ,037F</b>	<b>0383</b>
<b>DEC C</b>	<b>0385</b>
<b>JR Z,0370</b>	<b>0386</b>
<b>JR 0375</b>	<b>0388</b>

The requirements of a counter are these:

The computer must detect when a button is pressed and distinguish it from other buttons. In our design button A corresponds to BIT 7 and button B to BIT 6 of the accumulator.

The program must be running or LOOPING at all times ready to instantly pick up an input value.

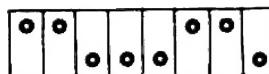
Because the program is running at high speed, we must include a DEBOUNCE feature to prevent more than ONE COUNT being registered when a button is pressed.

With these facts in mind, we have produced the 0-9 COUNTER.

The program contains 2 loops. One is executed when button 'A' is NOT pressed and the other when the button is PRESSED. We also have to detect when the end of the BYTE TABLE is reached.

## 0 - F COUNTER

This routine, at **0390**, increments the display each time button A is pressed.

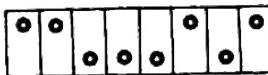


The main program for producing the letters on the display is located at **03A8** and the micro jumps to this address via the instruction **JR 03A8**. The main program is also used by the A-Z, 0-F counter and shows how the same table and output program can be accessed by two different START-UP ROUTINES.

<b>LD C,10</b>	<b>0390</b>	<b>0E 10</b>
<b>LD DE,03DF</b>	<b>0392</b>	<b>11 DF 03</b>
<b>LD HL,0390</b>	<b>0395</b>	<b>21 90 03</b>
<b>JR 03A8</b>	<b>0398</b>	<b>18 0E</b>

## A - Z, 0 - F COUNTER

This counter is located at **03A0** and



produces the letters A-F and hex values 0-F on the display via button 'A'.

<b>LD C,2A</b>	<b>03A0</b>	<b>0E 2A</b>
<b>LD DE,03C5</b>	<b>03A2</b>	<b>11 C5 03</b>
<b>LD HL,03A0</b>	<b>03A5</b>	<b>21 A0 03</b>
<b>IN A,(01)</b>	<b>03A8</b>	<b>DB 01</b>
<b>BIT 7,A</b>	<b>03AA</b>	<b>CB 7F</b>
<b>JR Z,03A8</b>	<b>03AC</b>	<b>28 FA</b>
<b>INC DE</b>	<b>03AE</b>	<b>13</b>
<b>LD A,(DE)</b>	<b>03AF</b>	<b>1A</b>
<b>OUT (02),A</b>	<b>03B0</b>	<b>D3 02</b>
<b>IN A,(01)</b>	<b>03B2</b>	<b>DB 01</b>
<b>BIT 7,A</b>	<b>03B4</b>	<b>CB 7F</b>
<b>JR NZ,03B2</b>	<b>03B6</b>	<b>20 FA</b>
<b>DEC C</b>	<b>03B8</b>	<b>0D</b>
<b>JR Z,03BD</b>	<b>03B9</b>	<b>28 02</b>
<b>JR 03A8</b>	<b>03BB</b>	<b>18 EB</b>
<b>JP (HL)</b>	<b>03BD</b>	<b>E9</b>

The 3 counters in this section use the table at **03C6**. The 0-9 counter uses only those bytes corresponding to 0-9. The 0-F counter uses bytes from 0 to the end of the table.

The A-Z, 0-F counter uses all the table.

In addition, the 0-F counter uses most of the A-Z, 0-F program and that's why it has only 4 instructions.

At **03C6**:

<b>A</b>	<b>77</b>	<b>V</b>	<b>1C</b>
<b>B</b>	<b>7C</b>	<b>W</b>	<b>4E</b>
<b>C</b>	<b>39</b>	<b>X</b>	<b>4C</b>
<b>D</b>	<b>5E</b>	<b>Y</b>	<b>6E</b>
<b>E</b>	<b>79</b>	<b>Z</b>	<b>1B</b>
<b>F</b>	<b>71</b>	<b>0</b>	<b>3F</b>
<b>G</b>	<b>3D</b>	<b>1</b>	<b>06</b>
<b>H</b>	<b>76</b>	<b>2</b>	<b>5B</b>
<b>I</b>	<b>06</b>	<b>3</b>	<b>4F</b>
<b>J</b>	<b>1E</b>	<b>4</b>	<b>66</b>
<b>K</b>	<b>72</b>	<b>5</b>	<b>6D</b>
<b>L</b>	<b>38</b>	<b>6</b>	<b>7D</b>
<b>M</b>	<b>47</b>	<b>7</b>	<b>07</b>
<b>N</b>	<b>37</b>	<b>8</b>	<b>7F</b>
<b>O</b>	<b>3F</b>	<b>9</b>	<b>67</b>
<b>P</b>	<b>73</b>	<b>A</b>	<b>77</b>
<b>Q</b>	<b>67</b>	<b>B</b>	<b>7C</b>
<b>R</b>	<b>33</b>	<b>C</b>	<b>39</b>
<b>S</b>	<b>6D</b>	<b>D</b>	<b>5E</b>
<b>T</b>	<b>78</b>	<b>E</b>	<b>79</b>
<b>U</b>	<b>3E</b>	<b>F</b>	<b>71</b>

By now you will be aware that certain combinations of hex values produce letters and numbers on the display.

Use the program at **0290** to produce the numbers 0-9 and letters A-F by switching ON the correct switches. Use the output display values on P68 to assist you in this. Add the value on the switches and compare with the table at **03C6**.

Register C is the counter for the BYTE TABLE. There are ten bytes. This DE register pair is loaded with the start-address of the byte table. The input latch is looked at and the value it holds is placed into the accumulator. The only line (or bit) which is tested is bit 7. This is the 8th line and is button A. If it is HIGH (or SET) the program advances. If it is LOW (or RESET), it goes to **IN A,(01)**. INCrement the DE register pair to look at address **03E0**. The byte at **03E0** is placed in the accumulator. Output this byte to the display. Look at the input port. Test bit 7 of the accumulator. Jump to address **037F** if button A is pressed. When button is released, advance to next line. Decrement the BYTE COUNT register. If end of table is reached, JUMP to start of program. If not reached, go to **0375**.

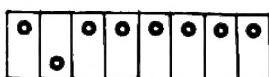
## 00 - 99 COUNTER

Counters and counting are a very important part of electronics. Business and industry needs counting. Whether it be to keep track of money or components, it needs to know the answers.

The counter program at 0400 shows the basics of how a counter operates and how the COUNT VALUE can be held in a single register pair.

Functions such as INCREMENT, DECREMENT and RESET can also be included. The most involved part of the program is debouncing the switches, to

prevent the count automatically incrementing if the button is kept pressed.



0400

at 03E0:

3F  
06  
5B  
4F  
66  
6D  
7D  
07  
7F  
67

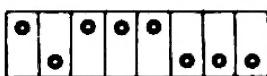
The program basically consists of two loops. The top loop is executed when the buttons are NOT pressed and the lower when either of the buttons is pressed.

This is necessary to keep the displays illuminated while at the same time preventing the program from incrementing the displays if a button is kept pressed.

LD E,00	0400	1E 00	Register E holds the present COUNT VALUE in decimal form.
LD A,E	0402	7B	Load E into the accumulator so that it can be operated upon.
AND 0F	0403	E6 0F	Mask off the 4 HIGH ORDER bits. In other words, remove them.
LD HL,03E0	0405	21 E0 03	Load HL with the start of the BYTE TABLE that produces the display numbers.
ADD A,L	0408	85	Add the start of the byte table to the accumulator.
LD L,A	0409	6F	Load the accumulator into L to produce a new pointer value.
LD A,(HL)	040A	7E	Load the accumulator with the byte pointed to by the HL register pair.
OUT (02),A	040B	D3 02	Output this value to port 2.
LD A,E	040D	7B	Load E into the accumulator again, this time to produce the 10's value.
RRA	040E	1F	Shift the bits in the accumulator one place to the right.
RRA	040F	1F	Shift the bits in the accumulator another place to the right.
RRA	0410	1F	" " " " "
RRA	0411	1F	" " " " "
AND 0F	0412	E6 0F	Mask the 4 HIGH ORDER bits so that they are effectively removed.
LD HL,03E0	0414	21 E0 03	Load HL with the start of the byte table.
ADD A,L	0417	85	Add the value of L to the value in the accumulator.
LD L,A	0418	6F	A new pointer value is created.
LD A,(HL)	0419	7E	Load the accumulator with the byte pointed to by the HL register pair.
SET 7,A	041A	CB FF	SET bit 7 of the accumulator to '1' to turn on the 10's display.
OUT (02),A	041C	D3 02	Output the value of the accumulator to the latch.
IN A,(01)	041E	DB 01	Input the value on the switches to the accumulator.
BIT 7,A	0420	CB 7F	TEST bit 7 to see if button A is pressed.
JR Z,042A	0422	28 06	If it is zero, jump to 024A. If it pressed, increment to next instruction.
LD A,E	0424	7B	Load E into the accumulator, ready for an INCrement operation.
INC A	0425	3C	Increment the accumulator.
DAA	0426	27	Decimal adjust the accumulator. This means an A will be changed into 10.
LD E,A	0427	5F	Save the new count value by loading it into the E register.
JR 0432	0428	18 08	Jump to 0431.
BIT 6,A	042A	CB 77	From 0422, the program jumps to this address and tests for button B.
JR Z,0422	042C	28 D4	If not pressed, the program jumps to 0402. If pressed, the program increments.
LD A,E	042E	7B	Load the COUNT REGISTER into the accumulator.
DEC A	042F	3D	Decrement the accumulator.
DAA	0430	27	Decimal adjust the accumulator. This will change a zero into a 9.
LD E,A	0431	5F	Save the count value by loading it into the E register.
LD A,E	0432	7B	{ The remainder of the program keeps both displays illuminated by looping from 0432 to 0456 while either of the buttons remains pressed. As soon as the button is released, the program jumps back to 0402 and executes the top loop. }
AND 0F	0433	E6 0F	
LD HL,03E0	0435	21 E0 03	
ADD A,L	0438	85	
LD L,A	0439	6F	
LD A,(HL)	043A	7E	
OUT (02),A	043B	D3 02	
LD A,E	043D	7B	
RRA	043E	1F	
RRA	043F	1F	
RRA	0440	1F	
RRA	0441	1F	
AND 0F	0442	E6 0F	
LD HL,03E0	0444	21 E0 03	
ADD A,L	0447	85	
LD L,A	0448	6F	
LD A,(HL)	0449	7E	
SET 7,A	044A	CB FF	
OUT (02),A	044C	D3 02	
IN A,(01)	044E	DB 01	
BIT 7,A	0450	CB 7F	
JR NZ,0432	0452	20 DE	
BIT 6,A	0454	CB 77	
JR NZ,0432	0456	20 DA	
JR 0402	0458	18 A8	

## DICE

The DICE Program at **0470** introduces a few more programming skills.



The first of these is a **RANDOM NUMBER GENERATOR**. Random numbers are almost impossible to generate via a computer due to it being a very predictable machine. The only reliable way to get a random number is to introduce the human element.

This is what we have done in this program.

At the start of the program a running LED routine moves a single LED around the 4x4 matrix. The ON time for each LED is created by a delay routine that uses the B and C registers. The C register is loaded with 6 and decrements to zero. Each time this is done, the B register is decremented and when it reaches zero, the LED jumps to the next location.

The random number is generated in the C register and we can exit from the program with a value remaining in C. Since C is the inside loop of the delay it is decrementing very fast and it is not possible to predict what value C will contain.

If it were the outside loop it would be a different matter. Players would gradually get to understand that pressing at the beginning of cycle would generate a low number and at the end of a cycle, a high number.

Owing to the unpredictability of the human reaction, an even spread of numbers from 1 to 6 is created with our routine.

The second feature of the program is the **COMPARE** and **BRANCH**.

After the random number has been obtained, a number of flashes are created on the screen and then the accumulator is compared with the random number before jumping to the display routine.

This routine is a very simple multiplexing routine in which three bytes are outputted for a period of 80 cycles.

The program then detects that the input button has been released and jumps to the start of the program.

If a button-check was not made, the same number would appear on the displays due to a constant number of cycles occurring in the program for each game.

**At 04D3:**

71	E1
72	E4
74	E2
78	E1
B8	D1
D8	B1

LD D,0C	0470	16 0C	C is the byte table counter for the 4x4
LD HL,04D3	0472	21 D3 04	HL will point to the byte table address
LD A,(HL)	0475	7E	A is loaded with the value of the first byte in the table
OUT (02),A	0476	D3 02	The accumulator is outputted to port 02
INC HL	0478	23	The byte table pointer is incremented
LD B,15	0479	06 15	Load B with 15, for a delay value of 21 loops
LD C,06	047B	0E 06	Load C with 6, for the dice values. 0-6
IN A,(01) ←	047D	DB 01	Input from the input port to the accumulator
BIT 7,A	047F	CB 7F	Check to see if button A has been pressed
JR NZ,048D	0481	20 0A	If pressnd, jump out of the delay routine
DEC C	0483	0D	Decrement register C
JR NZ,047D	0484	20 F7	If C is not zero jump up. If C zero, advance
DJNZ 047B	0486	10 F3	Decrement B and if not zero, jump up
DEC D	0488	15	Decrement the byte table register D
JR Z,0470	0489	28 E5	When D is zero jump to start of program
JR 0475	048B	18 E8	If not zero, continue DELAY ROUTINE
LD D,06 ←	048D	16 06	Load D with 6 for six flashes of the display
LD A,0F	048F	3E 0F	Load A to turn on the whole 4x4 display
OUT (02),A	0491	D3 02	Output to port 02
DJNZ 0493	0493	10 FE	Register B is decremented to create a delay
LD A,FF	0495	3E FF	Load A with a value to turn 4x4 OFF
OUT (02),A	0497	D3 02	Output to port 02.
DJNZ 0499	0499	10 FE	Create a short delay with register B
DEC D	049B	15	Decrement the flash-count register
JR NZ,048F	049C	20 F1	Loop for 6 flashes
LD D,80	049E	16 80	Load D for 80 loops for multiplexing routine
LD A,C	04A0	79	Load our random number into the accumulator
LD HL,04E0	04A1	21 E0 04	Load HL with address of table for multiplex routine
CP 01	04A4	FE 01	Compare the accumulator with 1
JP Z,045F	04A6	CA F5 04	If the accumulator is 1, jump to multiplex routine
LD HL,04E3	04A9	21 E3 04	Load HL with start address for displaying '2
CP 02	04AC	FE 02	Compare the accumulator with 2
JP Z,045F	04AE	CA F5 04	If accumulator is 2, jump to multiplex routine.
LD HL,04E6	04B1	21 E6 04	Load HL with start address for displaying '3
CP 03	04B4	FE 03	Compare accumulator with 3
JP Z,045F	04B6	CA F5 04	If accumulator is 3, jump to multiplex routine
LD HL,04E9	04B9	21 E9 04	Load HL with start address for displaying '4
CP 04	04BC	FE 04	Compare the accumulator with 4
JP Z,045F	04BE	CA F5 04	If accumulator is 4, jump to multiplex routine.
LD HL,04EC	04C1	21 EC 04	Load HL with start address for displaying '5
CP 05	04C4	FE 05	Compare accumulator with 5
JP Z,04F5	04C6	CA F5 04	If accumulator is 5, jump to multiplex routine.
LD HL,04EF	04C9	21 EF 04	Load HL with start address for displaying '6
CP 06	04CC	FE 06	Compare accumulator with 6
JP Z,04F5	04CE	CA F5 04	Jump to multiplex routine if accum is 6
A jump value must be found and the micro jumps to the multiplexing routine below and produces a display on the 4x4 that is similar to the spots on the face of a dice. The routine runs for 80 loops. makes sure button A is not pressed, then jumps to the start of the DICE program			
<b>At 04E0:</b>			
B4	D2	72	52
00	00	B4	00
00	78	D8	58
LD A,(HL)	04F5	7E	Load A with the value pointed to by HL
OUT (02),A	04F6	D3 02	Output the value to port 02
LD B,0A	04F8	06 0A	Load B with a short delay value.
DJNZ 04FA	04FA	10 FE	Create a short delay with register B
INC HL	04FC	23	Point to next display address
LD A,(HL)	04FD	7E	Load the value pointed to by HL into A
OUT (02),A	04FE	D3 02	Output to port 02.
LD B,0A	0500	06 0A	Load B with a short delay value.
DJNZ 0502	0502	10 FE	Create a short delay with register B
INC HL	0504	23	Inc HL to look at next address
LD A,(HL)	0505	7E	Load value pointed to by HL in the accumulator.
OUT (02),A	0506	D3 02	Output to port 02
LD B,0A	0508	06 0A	Load register B with a short delay value
DJNZ 050A	050A	10 FF	Decrement register B to zero.
DEC HL	050C	2B	Dec HL to look at start of display table
DEC HL	050D	2B	
DEC D	050E	15	Decrement multiplex routine loop counter.
JR NZ,04F5	050F	20 E4	Loop again if D is not zero.
XOR A	0511	AF	Zero the accumulator and output to port 02 to blank the display.
OUT (02),A	0512	D3 02	Look at the output port to see if button A is NOT
IN A,(01)	0514	DB 01	pressed before re-starting the DICE program.
BIT 7,A	0516	CB 7F	Loop is A is pressed.
JR NZ,0514	0518	20 FA	Jump to start of DICE program
JP 0470	051A	C3 70 04	

# Z80

# Machine Codes EXPLAINED Part II

SHEET 14.

NEG . . . .	Each bit in the accumulator is reversed sign. One's go to zero and zero's go to one. Then one is added to the result.	RLD . . . .	The 4 low-order bits of a memory location (pointed to by the contents of register pair in brackets) are transferred to the 4 high-order bits of the same memory location. The 4 high-order bits are transferred into the 4 low-order bits of the accumulator. The previous 4 low-order bits of the accumulator are transferred to the 4 low-order bits of the memory location specified above.
NOP . . . .	The NO OPERATION instruction. Only the Program Counter advances.	RR ( ) . . . .	Rotate the contents of a memory location pointed to by the contents of the register in ( ) to the right, through the carry bit.
OR ( ) . . . .	The logic OR operation is performed between the accumulator and the contents of the memory location pointed to by the address in ( ).	RR A,B,C etc . . . .	Rotate the indicated register to the right through the carry bit.
OR A,B,C etc . . . .	A logic OR operation is performed between the accumulator and a specified register.	RRA . . . .	Rotate the accumulator right, through the carry bit.
OTDR . . . .	Data from the memory location specified by the contents of the HL register is outputted to a port as specified by the contents of register C. The HL pointer has its value decremented after each transfer operation. The value of register B is decremented and if the result is zero, the Program Counter register is set back 2 units so that the instruction is re-executed.	RRC ( ) . . . .	Rotate the contents of a memory location pointed to by the contents of the register in ( ) to the right but not through the carry bit. The C flag is set to the status of the register's least significant bit.
OTIR . . . .	Same OTDR except that the HL pointer is incremented after each execution.	RRC A,B,etc . . . .	Rotate register to the right but not through the carry bit.
OUT (C),A etc . . . .	The contents of A, B, C, D, etc are outputted to the port specified by the contents of register C.	RRCA . . . .	A one-byte instruction for RRC A.
OUT port,A . . . .	The contents of the accumulator is outputted to the port specified.	RRD . . . .	The 4 high-order bits of a memory location (pointed to by the contents of register pair HL) are transferred to the 4 low-order bits of the same location. The 4 low-order bits are transferred to the 4 low-order bits of the accumulator. The previous 4 low-order bits of the accumulator are transferred to the 4 high-order bits of the memory location specified above. A special one-
OUTD . . . .	Data is outputted from memory location specified by the contents of the HL register pair to the port specified by the contents of register C. (contents of register B will be decremented but no repeat operation will be performed.) HL register pair has its contents decremented after the conclusion of the operation.	RST 00 . . . .	A special one-byte subroutine call directive called RESTART. RST 00 will restart at page zero, location 00, i.e. 00 00 RST 08 will restart at location 08, i.e. 00 08 etc.
OUTI . . . .	Same as OUTD except HL has its contents incremented at the conclusion of the operation.	SBC A,( ) . . . .	Subtract the contents of memory pointed to by the contents of the register pair in ( ) and the carry flag from the accumulator. Store the result in the accumulator.
POP AF . . . .	Two bytes are removed from the stack. The first byte is loaded into F and the second into A.	SBC A,B . . . .	The contents of the B register and the carry flag (the C flag in the F register) are subtracted from the contents of the accumulator. The result is stored in the accumulator.
PUSH HL . . . .	Two bytes are placed onto the stack. The contents of the HIGH ORDER register are stored in the stack at the address of the stack pointer less one. The content of the LOW ORDER register are stored at the address of the stack pointer less two.	SCF . . . .	The carry flag (the C flag in the F register) is set to 1.
RES 0,( ) . . . .	RESET BIT 0, 1, 2, 3, 4, 5, 6, 7 to the logic ZERO condition of the specified register.	SET 0,( ) . . . .	Bit 0, etc of the memory location pointed to by the contents of the register in ( ) is set to 1.
RET . . . .	The unconditional RETURN instruction	SET 0,B . . . .	The indicated bit in the selected register is set to 1.
RET C . . . .	Return from the sub-routine if the carry flag in the F register is true (1).	SLA ( ) . . . .	SHIFT LEFT ARITHMETIC. Shift the contents of the memory location pointed to by the contents of the register in ( ) one bit to the left, resetting the least significant bit to 0.
RET M . . . .	The instruction will only be performed if the S flag (sign flag) is negative.	SLA A,B,etc . . . .	Shift the contents of the specified register left one bit, resetting the least significant bit to 0.
RET NC . . . .	The instruction will only be performed if the NON-CARRY condition is present. i.e. the CARRY FLAG is '0'.	SRA ( ) . . . .	SHIFT RIGHT ARITHMETIC. Shift the contents of a memory location pointed to by the contents of the register in ( ) to the right. The high-order bit is not altered. Bit 0 is shifted into the carry bit.
RET NZ . . . .	The instruction will only be performed if a NON-ZERO condition is satisfied, i.e. the ZERO FLAG is '0'.	SRA A,B,etc . . . .	Shift the contents of a register one bit to the right. High-order bit is unchanged. Bit 0 is shifted into the carry bit.
RET P . . . .	The instruction will only be performed if the sign flag in the F register is positive, i.e. S = 1.	SRL ( ) . . . .	SHIFT RIGHT LOGICAL. The contents of the memory location pointed to by the contents of the register in ( ) are shifted to the right. Bit 7 is reset to 0. Bit 0 is shifted into the carry bit.
RET PE . . . .	The instruction will only be performed if the PARITY is EVEN. This means the P/V flag is SET (1).	SRL A,B,etc . . . .	The contents of the indicated register is shifted one bit position to the right. Bit 7 is reset to 0. Bit 0 is shifted into the carry bit.
RET PO . . . .	The instruction will only be performed if the PARITY is ODD. This means the P/V flag is reset (0).	SUB ( ) . . . .	Subtract the contents of the memory location pointed to by the contents of the register in ( ) from the accumulator.
RET Z . . . .	The instruction will only be performed if the ZERO flag is SET (1).	SUB A,B,etc . . . .	Subtract the contents of the specified register from the accumulator.
RETI . . . .	Return from INTERRUPT.	SUB dd . . . .	Subtract immediate data from the accumulator.
RETN . . . .	Return from non-maskable INTERRUPT.	XOR ( ) . . . .	Perform the Exclusive-OR operation on data pointed to by the contents of the register in ( ) with the accumulator.
RL ( ) . . . .	The content of the memory location contained in ( ) is rotated to the left, through the carry bit.	XOR A,B,etc . . . .	Exclusive-OR the contents of the specified register with the accumulator.
RL A,B,C,etc . . . .	The contents of the register is rotated one bit position to the left, through the carry bit.	XOR dd . . . .	Exclusive-OR the immediate data with the accumulator.
RLA . . . .	This is a one-byte instruction of RL A and rotates the contents of the accumulator one bit position to the left, through the carry bit.		
RLC ( ) . . . .	The contents of a memory location pointed to by the contents of the location in ( ) is shifted one bit to the left but not through the carry. The C flag is set to the original status of the register's least significant bit.		
RLC A,B,etc . . . .	The contents of the indicated register is shifted one bit position to the left. It does not shift through the carry bit but does set the C flag to the original status of the register's most significant bit.		
RLCA . . . .	This is a one byte instruction of RLC A and operates as above.		